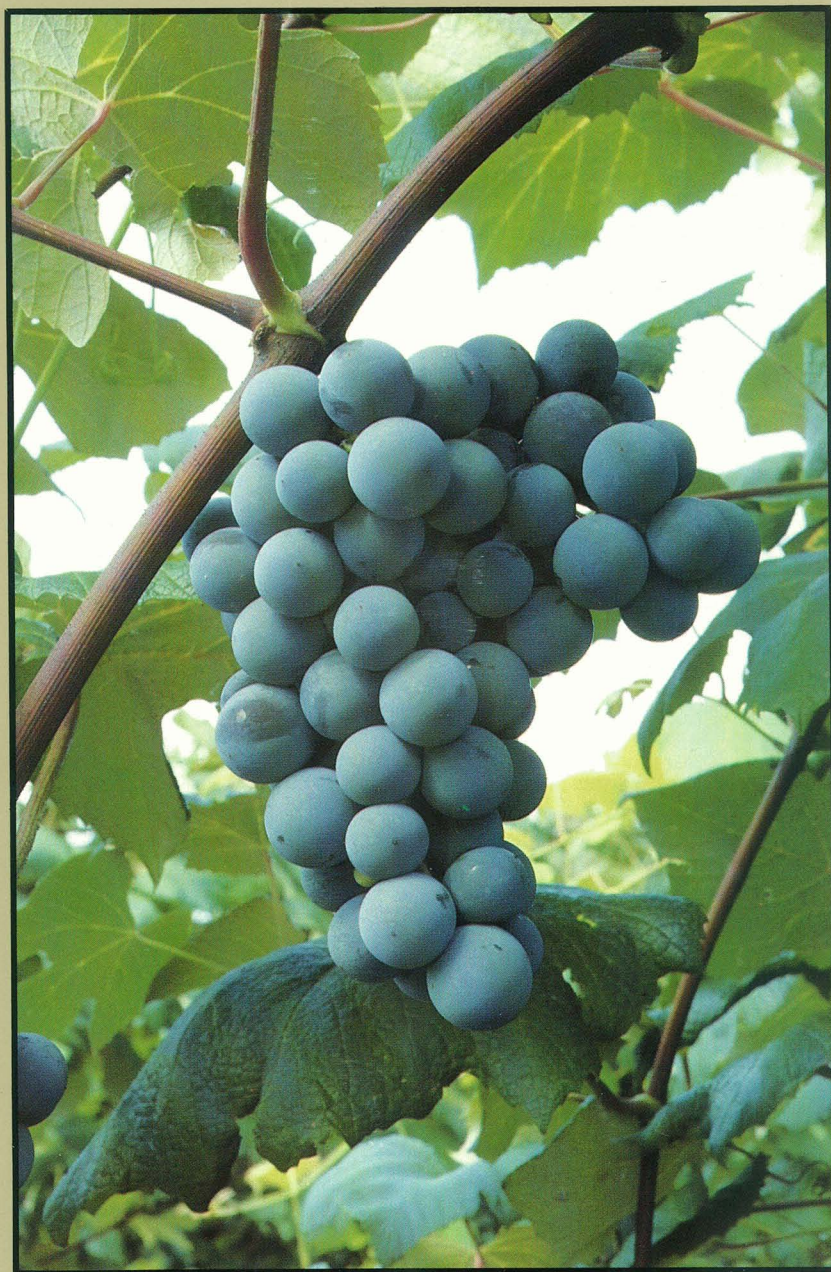


A manual for · GROWERS



CONCORD · Table Grapes

CONCORD • *Table Grapes*

Economics, Production, Harvesting, Storage, Concord-Type Varieties

A manual for • GROWERS

June 1988

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INTRODUCTION

The Concord grape with its unique flavor has been recognized as a quality table grape for more than a century. Concord acreage began to grow significantly in New York in the 1860's, but it wasn't until the 1880's that they began to be marketed in significant quantities. By the start of the 20th Century the Concord table grape market dominated New York's viticulture. For example, in 1900 the Chautauqua grape belt marketed 8,000 carloads of table grapes, most of them Concord. In 1906 carload shipments of table grapes accounted for 85% of the grape market for this region.

Several major factors including expanding, profitable, alternate markets for Concord; changes in the table grape market; and a trend toward increased mechanization on New York grape farms led to a decline in the size of the New York Concord table grape industry. Nevertheless, this market has continued to be a viable alternative for Concord grapes. In recent years, the consumption of Concord table grapes has been growing as a part of a national trend of increased consumption of fresh fruit. Grapes now rank third among fruit in per capita consumption. Without doubt consumers prefer seedless table grapes over seeded varieties. Nevertheless, the unique flavor of Concord and its association with delicious jams, jellies and juices continues to attract a loyal following.

New York Concord growers have experienced a difficult market situation over the past decade. Many have looked at the table grape market as a possibility for their crop. New York grape growers have a long and talented history in the production of Concord grapes. However, many have not been involved in table grape marketing in recent years, if ever.

There has been no attempt to present in this publication all aspects of Concord grape production. Therefore, other sources of information including Cornell Misc. Bulletin #111, "Cultural Practices For Commercial Vineyards" should be used as a complement to this bulletin. Our efforts in this presentation have been focused on two matters of prime importance to the Concord table grape grower - yield and fruit quality.

EVALUATING THE ECONOMICS OF CONCORD TABLE GRAPES

Although the market for Concord table grapes has been expanding, few if any new Concord vineyards have been planted for this purpose. Rather, the expansion of Concord table grape marketing in New York has predominantly resulted from a diversification of the marketing of grapes from existing vineyards. When growers consider a table grape enterprise, important economic questions arise. What are the additional costs of Concord table grape production and marketing beyond those involved with growing Concord for a processing market? Are Concord table grapes profitable enough to justify those additional costs?

The following discussion has been prepared to help growers answer these questions for their own specific situations. The example values we present in this discussion are useful only to indicate the mathematical sequence of the calculations. They have no bearing on the actual economics of a particular grape farm. The only economic analysis that will be of true value

to a grower is the one based on his own situation. The following "workbook" exercise provides the framework to make an economic projection for a Concord table grape enterprise. Please make your own set of assumptions and estimates in Table 1 before proceeding further.

TABLE 1. A set of assumptions and estimates to be used in making an economic projection for a Concord table grape enterprise.

	<u>Example Values</u>	<u>Your Values</u>
(A) Yield Per Acre (Tons)	5.5	_____
(B) % of crop for fresh fruit	75%	_____
(C) Tons of Fresh Fruit Marketed per acre (A X B) (5.5 x .75)	4.1	_____
(D) % of crop marketed for processing	25	_____
(E) Cost of Packaging per ton		
if 8 qt. baskets	\$45	_____
if lugs (80-100/ton)	\$90	_____
if 12-1 qt. units (100/ton)	\$160	_____
(F) Cost of Package Assembly per ton	25	_____
(G) Cost per ton to transport packaging in and out of the vineyard with supervision	42	_____
(H) Transportation to market per ton	15	_____
(I) Marketing Costs Per Ton	3	_____
(J) Temporary storage costs per ton	3	_____
(K) Hand harvest per ton	110	_____
(L) Additional employee benefits per ton (SS. + Workman's Comp)	17	_____
(M) Additional Growing Costs per acre for Fresh Fruit (Alar spray plus more intensive pesticide spray program)	\$70	_____
(N) Cost per ton for Mechanical Harvest	\$35	_____
(O) Cost per ton for delivery to processing	\$10	_____
(P) Minimum price per acre for mechanical harvest	\$100	_____
(Q) Grape Prices per ton - Fresh Market	\$595	_____
(R) Grape Prices per ton - Processing	\$175	_____

Partial Budgeting of The Economics of Concord Table Grape Production and Marketing

A grower can use partial budgeting to determine if Concord table grape marketing will improve his economic condition in comparison to his current processing market. This requires a consideration of only those items which add to net income (added returns and/or reduced costs) and those items which reduce net income (reduced returns and/or added costs). Fixed costs (machinery depreciation, interest, taxes, insurance, etc) and many of the production costs do not change. Therefore, they need not be considered when estimating how the economics of a Concord vineyard will change.

The outline in Table 2 provides the structure with which to perform this partial budgeting technique. A grower should use his values from Table 1 to calculate his own analysis.

TABLE 2. - A partial budget for analyzing the profitability of a Concord table grape enterprise. The letters in parenthesis refer to items listed in Table 1. A grower should complete the "your values" column in Table 1 before using the outline below.

Items adding to the cost or reducing the return to the operation.		Items reducing the cost or adding to the returns of the operation.	
<u>Example Values</u>	<u>Your Values</u>	<u>Example Values</u>	<u>Your Values</u>
Fruit not processed (C X R) 4.1 X 175 = \$718	<u> x </u> = _____	Fresh Fruit sold (C X N) 4.1 X \$595 = 2454	(<u> x </u>) = _____
Packaging (C X E) 4.1 X \$160 = \$656	<u> x </u> = _____		
Packaging Assembly (C X F) (4.1 X 25) = 103	(<u> x </u>) = _____		
Transport of boxes in and out of vineyard (C X G) (4.1 X 42) = 172	(<u> x x </u>) = _____	Elimination of normal harvest and trucking costs for fruit sold to processing AX(N+O) 5.5X(35+10) = 248	<u> x (+)</u> = _____
Packing Fruit (C X K) (4.1 X 110) = 451	(<u> x </u>) = _____		
Additional labor Costs (C X L) (4.1 X 17) = 70	(<u> x </u>) = _____		
Additional production costs (M) = 70	_____		
Transport of fresh fruit to market (C X H) (4.1 X 15) = 62	(<u> x </u>) = _____		
Marketing Costs (C X I) 4.1 X 3 = 12	(<u> x </u>) = _____		
Temporary storage costs (C X J) (4.1 X 3) = 12	(<u> x </u>) = _____		
Harvest & trucking for tons processed (P + A X D X O) 100 + 5.5 X .25 X 10 = 114	<u> + x x </u> = _____		
Subtotal of Additional Costs and reduced returns \$2,440	_____	Subtotal of Reduced Costs or additional returns \$2,702	_____

Based on our example values, the hypothetical grower would receive \$262 more per acre by selling his crop for fresh fruit. Different assumptions would change the net outcome of the calculation. For example, if all the example assumptions above were to remain the same except that the yield per acre were estimated at 4.0 tons per acre rather than 5.5 tons per acre, then the grower would receive only \$135 more per acre for his crop by selling it for fresh fruit rather than for processing. If another assumption were changed to assume only 50% utilization of fruit for fresh market, then the gain is only \$80 per acre to become involved in fresh fruit marketing. These figures illustrate that growers must use their own figures with this outline to obtain a meaningful analysis of their own situation. They also point out the importance of high yields and a high percentage pack out for fresh market to make table grape marketing economically worthwhile.

When a grower has analyzed his own economics, he then has a basis upon which to proceed with or abandon plans for the fresh fruit marketing of Concord. If the decision is to proceed, records of the costs and returns of the table grape enterprise should be kept so that periodically a revised economic projection can be made with more accurate information.

CULTURAL PRACTICES

Introduction

All the practices a grower applies to his Concord table grape vineyard are concerned with two basic goals - yield and fruit quality. Long term large yields depend upon a combination of medium to large vine size and proper vine management for the expression of fruiting potential. This discussion emphasizes the development and maintenance of large vine size through the practices of vineyard floor management, vineyard nutrition, training and pruning. Because training and pruning are also fundamentally important for the expression of fruiting potential, we have given emphasis to these two viticultural practices. Fruit quality is just as important as yield for the table grape grower. Today's consumer is able to get, and therefore, expects ever increasing product quality. Table grape quality is a complex of factors. It is not simply fruit maturity. Visual factors such as cluster compactness, berry size, coloration and freedom from defects, such as those caused by pests or pesticide spray residues, are as important as fruit maturity to overall fruit quality. Therefore, those cultural practices which have a major impact on these aspects of fruit quality (Table 3) are discussed. Although this entire presentation is specifically oriented to the production of Concord table grapes in mature vineyards, much of this discussion has application to the management of other varieties.

Table 3 - Cultural practices which a grower can use to directly affect yield, maturity, cluster compactness, berry size and general appearance of Concord table grapes.

AREA OF INFLUENCE	DOMINANT CULTURAL PRACTICES
Yield	Training, Pruning, Nutrition, Vineyard Floor Management
Fruit Maturity	Training, Pruning, Potassium Nutrition
Cluster Compactness (berries/cluster)	Training, Pruning, Nutrition, Special Practices
Berry Size	Training, Pruning, Vineyard Floor Management, Potassium & Boron Nutrition, Special Practices
General Fruit Appearance	Pesticide Spray Program

PRUNING

Pruning has a large influence on the performance of Concord grapevines. Growers realize the importance of pruning and they invest more resources into this task than any other aspect of grape growing. The following discussion reviews many of the factors to consider when pruning a grapevine.

Pruning Severity

How much woody growth should be pruned from a Concord grapevine during the winter? More importantly, how many nodes (buds) should be left? It wasn't until the 1920's that a direct relationship was established between the size of a Concord grapevine and the appropriate severity of pruning. N.L. Partridge (1925) was the first to promote the concept of balanced- pruning, which aims to have the vine bear fruit in relation to its capacity as measured by its growth in the previous year. This approach requires a pruner to learn to estimate the amount one-year wood (canes) on a dormant vine. Concord vines on typical 7-8 foot vine spacings are considered small, medium or large if they have 1 or less, 2 to 3, or more than 3 pounds of cane prunings, respectively. To develop the ability to estimate vine size, one estimates the weight of canes on a vine, prunes the vine, and then actually weighs the cane prunings (one-year wood) to determine the accuracy of the estimate. Only the canes are weighed! After pruning and weighing several vines, most people are able to estimate vine size as determined by the pruning weight of canes. Partridge originally suggested that 30 nodes be retained for the first pound of cane prunings on a Concord vine and that 8 nodes be retained for each succeeding pound of cane prunings. That original Concord pruning formula of $30 + 8$ has become slightly modified so that today a pruning formula of $30 + 10$ is considered appropriate for the production of quality Concord table fruit. Research has shown that less severe pruning to a formula of $50 + 10$ (Cawthon & Morris, 1977) or $60 + 10$ (Shaulis & Steele, 1969) will result in higher yields but significantly less fruit maturity. In practice, this means that if a grower leaves as little as two additional 10-node canes beyond the $30 + 10$ pruning severity, the quality of the fruit will be measurably reduced. Therefore, Concord vines which are to be pruned for the production of table fruit should be carefully pruned to a $30 + 10$ pruning formula. A maximum of 60 nodes should be retained on typical single-curtain trained vines planted 7-8 feet apart in 9 foot rows.

Choosing Nodes for Fruiting

Choosing high quality nodes to retain for fruiting is at least as important as leaving the correct number of nodes. Partridge (1921, 1922) and Clark (1926) thoroughly evaluated the influence of several cane characteristics on the yield and fruit quality of Concord grapevines. Factors which can help in the selection of high quality, fruitful nodes include the following:

- **Cane Length** - Many researchers early in this century labored to measure the fruitfulness of nodes at positions along Concord canes. Unfortunately, this work was performed without the realization that the fruitfulness of an individual node is highly influenced by its exposure to sunlight during development (Shaulis et al., 1966). Therefore, the early studies typically, but erroneously, concluded that the basal three nodes on Concord canes were inherently inferior in fruitfulness to those further out on the cane. However, today we realize that the

reason these early studies observed low fruitfulness in the basal nodes was that the systems of training being used at that time caused the basal nodes to develop in greater shade than those nodes further out on the cane. Research by Cawthon and Morris (1977) has shown that the basal three nodes of Concord canes can be highly fruitful if they develop with good exposure to sunlight during the previous growing season.

This knowledge suggests that growers should minimize the proportion of nodes retained for fruiting, which have developed in shade. For example, when the Umbrella Kniffin training system is used, the basal three nodes of fruiting canes are typically less fruitful than those further out the cane. If a grower is using this training system, the use of long fruiting canes will reduce the proportion of inferior nodes, which are retained at the base of canes. If 60 nodes were to be retained on a vine, the use of four 15-node canes (Figure 1) or five 12-node canes would retain fewer inferior nodes than if six 10-node canes were used (Figure 2). When Umbrella-Kniffin training is used, the limit on fruiting cane length will depend upon the maturity of the canes and one's ability to distribute and tie long canes on the trellis.

When using training systems which minimize the shading of fruiting canes during their development, such as Geneva Double Curtain, there is no reason to use long fruiting canes.

- Cane Diameter - Very large diameter canes are in general more susceptible to winter injury than smaller diameter canes. Although this may be of commercial concern for cold tender varieties, it is often possible to use large diameter canes without hazard on the winter cold hardy Concord variety.

- Persistent Lateral Canes - There is a qualification to the use of large diameter canes on Concord vines. Those which have persistent lateral canes (Figure 3a) require special treatment. Buds on primary canes at the base of persistent lateral canes are often of poorer fruiting

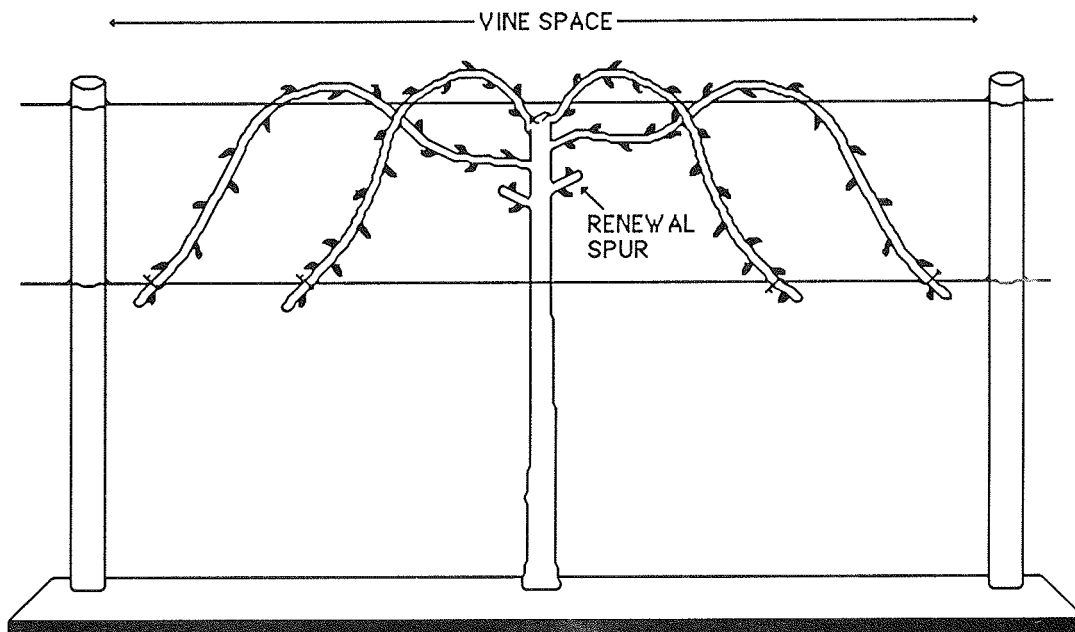


Figure 1 - A vine trained Umbrella Kniffin showing the effective use of long fruiting canes to distribute nodes well within the vine space.

quality and less winter hardy than other buds on the primary cane or those on the persistent lateral cane. Therefore, to ensure high production from canes with persistent laterals, one node of the persistent lateral should be retained to form a so-called spurred lateral (Figure 3b). Cooper and Vaile (1939) compared the production of 12-node large diameter canes with persistent laterals removed (Figure 3c) or retained (Figure 3b). The canes with spurred persistent laterals yielded 338% more fruit than canes without the persistent laterals (1.3 lbs. vs. 5.7 lbs. per cane). When counting all nodes on both the primary cane and the persistent laterals, the canes with persistent laterals yielded 46% more fruit per node than those without persistent laterals (0.158 lbs/node versus 0.108 lbs/node). Therefore, whenever large diameter canes with persistent laterals are used for fruiting, the persistent laterals should be spurred.

The pruning of persistent laterals to 1-node spurs is the most common and recommended approach to handling persistent laterals. However, it should be noted that many growers make use of well-developed laterals by retaining several nodes on a persistent lateral rather than continuing out the primary cane. (Figure 3d). Cooper & Vaile (1939) indicate that if the persistent laterals are well developed, this practice can provide nodes that “closely approximate, in performance, regular canes”.

- **Cane Color** - Concord canes, which have developed in sunlight, have a rich, shiny, dark brown color and should be chosen for fruiting canes whenever possible. By comparison canes developing in shade are lighter brown in color with a dull appearance.

- **Internode Length** - High quality, fruitful canes develop from shoots growing in sunlight. They are indicated by shorter internodes than those on less fruitful shoots, which develop in the shade.

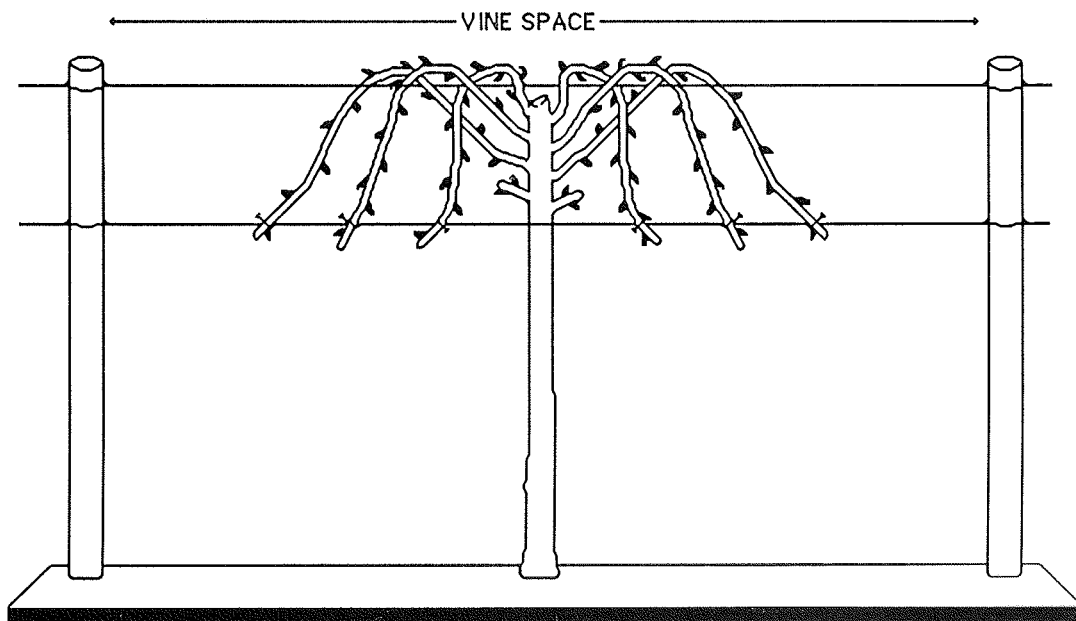


Figure 2 - A vine trained Umbrella Kniffin showing the congested placement of nodes within the vine space resulting from the use of relatively short fruiting canes.

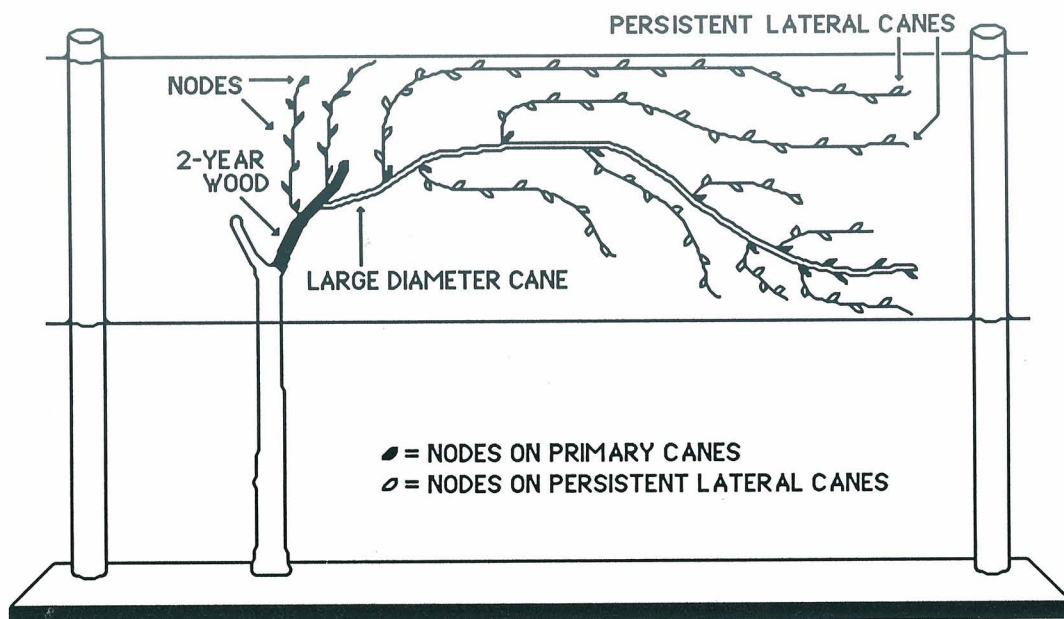


Figure 3a.

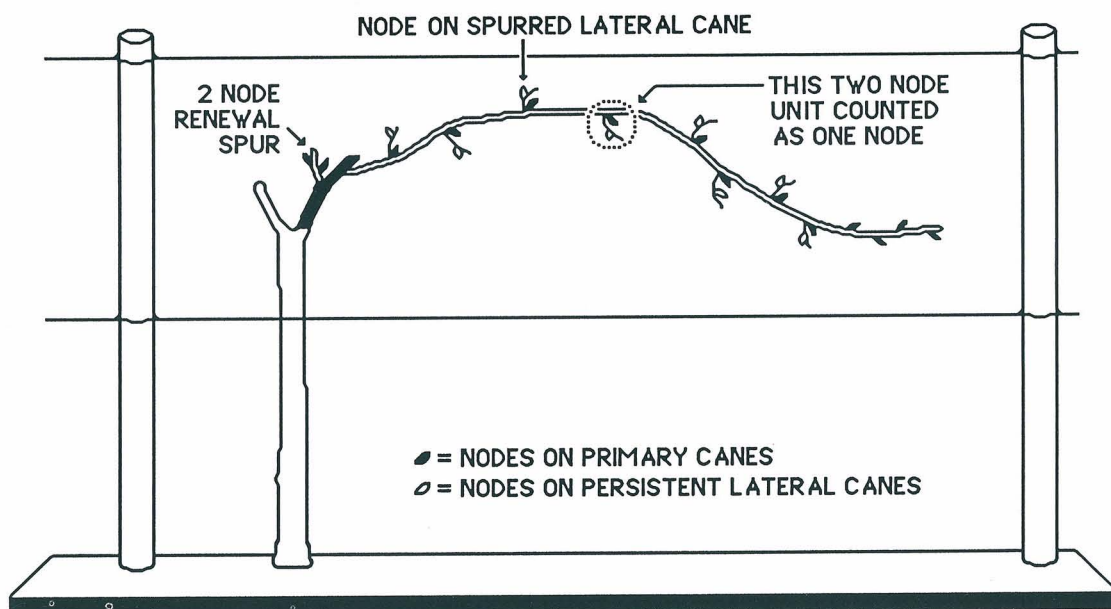


Figure 3b.

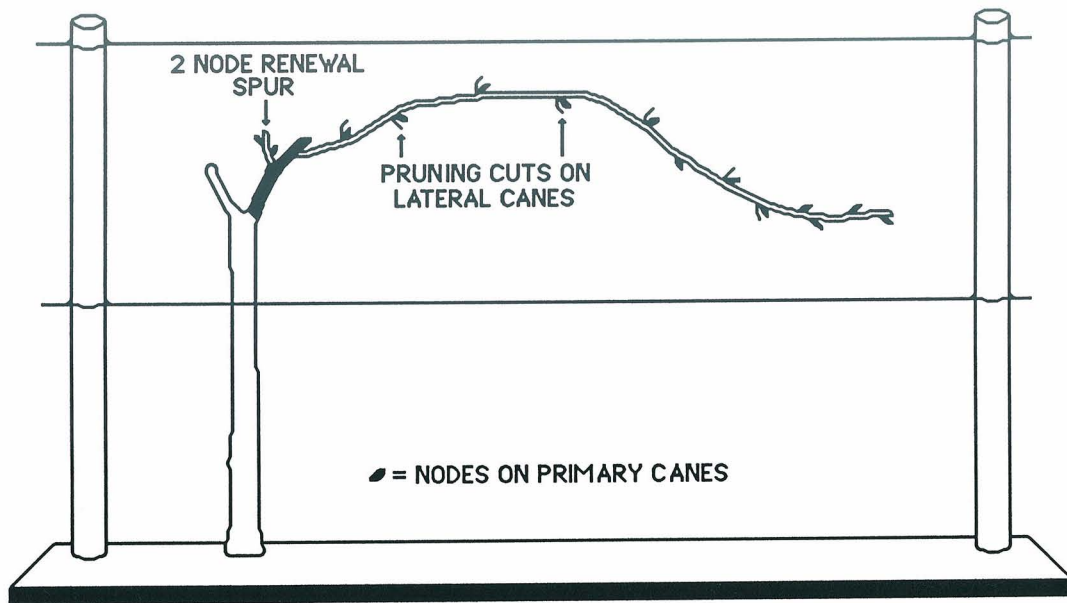


Figure 3c.

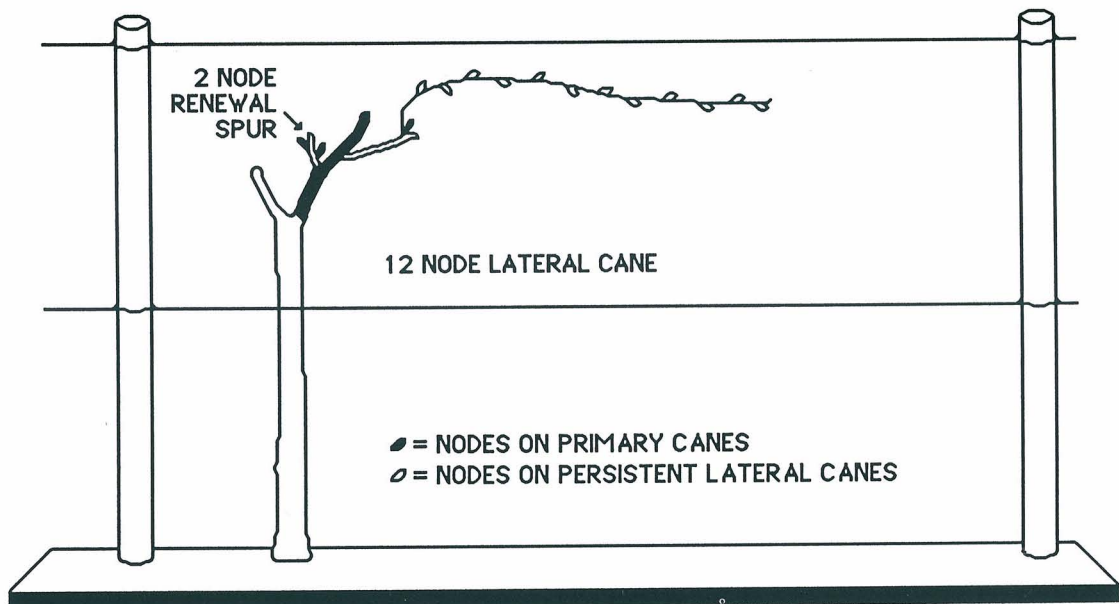


Figure 3d.

Figure 3 - A portion of a dormant vine showing: (a) a large cane upon which there are several persistent lateral cane, (b) the proper pruning of that large diameter cane by leaving one node spurs on each of the eight persistent lateral canes, (c) the improper pruning of that large cane by removal of all nodes on the persistent lateral canes, and (d) another approach to pruning a large diameter cane by retaining twelve nodes on one of the well developed persistent lateral canes.

Maintaining the Growth Form of a Vine

Another aspect of pruning a grapevine is the maintenance of the structure of the vine. Two strategies for fulfilling that goal are:

- **Renewal Spurs** - A renewal spur is a cane, which is pruned back to one or two nodes for the purpose of promoting shoot growth in the renewal zone of the vine. The intention is that shoots from these spurs will develop into quality canes which can be retained for fruiting the following year. When Umbrella Kniffin training is used, renewal spurs are generally placed basal to fruiting canes (Figure 1). When vines are trained Hudson River Umbrella (HRU) or Geneva Double Curtain (GDC), renewal spurs should be kept along the cordons among the longer fruiting canes (Figures 19 & 20). If the renewal zone is well exposed to sunlight, such as in GDC training, the nodes on renewal spurs should be counted as part of the total count of nodes retained. For vines trained with a shaded renewal zone, as is often the case with Umbrella Kniffin training, the nodes on renewal spurs are not included in the

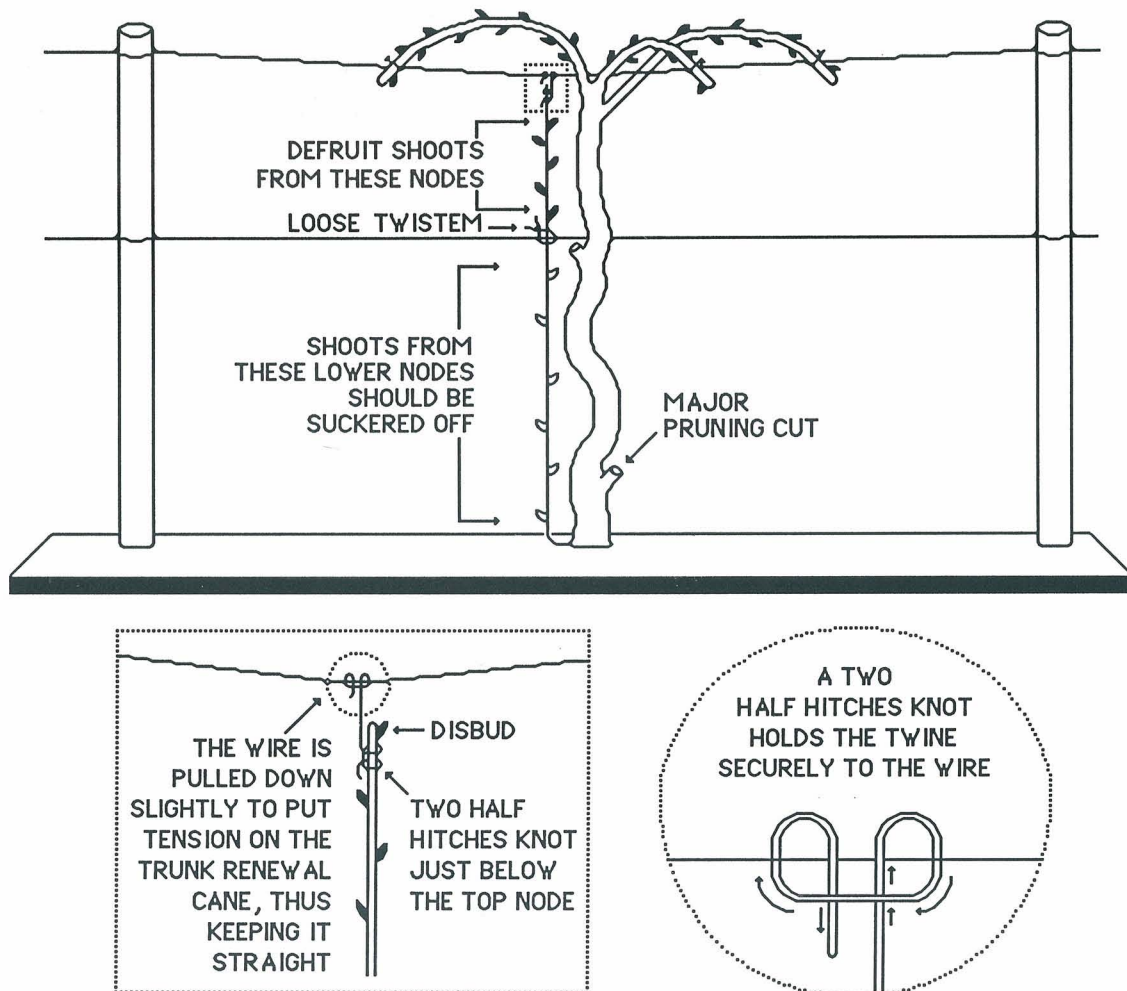


Figure 4 - The age, curvature and large pruning wounds on the trunk of this vine as well as the inability to locate pruning canes below the top wire of the trellis suggest it is time to renew the trunk of this vine. The details of handling a trunk renewal cane are indicated.

count of nodes retained because they typically do not contribute significantly to the crop load on the vine.

- **Trunk Renewals** - Even though Concord vines are quite winter hardy, trunks should be replaced every 10-12 years to avoid losses due to diseases such as Eutypa dieback. Therefore, canes from suckers, which have developed from the ground or as close as possible to the ground, should be retained periodically to begin a new trunk. A good method of trunk renewal involves pruning renewal canes to a length just below the top wire (Figure 4). When shoot growth begins, remove shoots on the trunk renewal cane up to the bottom of the renewal zone and defruit the remaining shoots. Renewal canes can be string tied to the top wire with some tension from the top wire to keep them straight (Figure 4). In subsequent years retain as many nodes on these new trunks as can be handled in a practical manner. Eliminate the old trunk as soon as the full node count can be placed on the new trunk.

Thorough suckering over a several-year period can lead to “sterile” bases of vines from which no trunk renewal canes can be obtained. Therefore, it may be beneficial to leave one or more suckers at the base of a vine for the purpose of developing a reservoir of base buds even in years when trunk renewal is not desired.

Distributing Vine Growth on the Trellis

Yet another consideration in pruning is to have shoot growth well distributed on the trellis. This typically involves selecting the number of fruiting canes for each side of the vine space as equally as possible. For example, for a vine trained Umbrella Kniffin with about 3 lbs. of cane prunings and pruned to a 30 + 10 pruning formula, one might leave two 13-node canes on each side of the vine space. For vines trained HRU or GDC, good distribution means spacing fruiting canes as evenly as possible along the cordon and, to the extent possible, selecting canes from the bottom of the cordon (lower 180 degrees) to facilitate the process of shoot positioning.

Filling-in the Gaps

A major cause of reduced yield in some Concord vineyards is a lack of trellis fill caused by missing vines. The best and most practical way of filling in such gaps is layering. This is accomplished by leaving a very long cane on a vine adjacent to a vacant vine space. In the spring a hole is dug about 12" - 15" deep in the vacant space (Figure 5). The long cane is bent in a U-shape into and out of this hole so that three or more nodes are located on the end of the cane above the ground level. All shoots which develop on this cane up to the point where it enters the ground are removed. Shoots on the apical portion of the layer should be defruited. If this is not done, these should be taken into account when performing balanced pruning.

When the portion of the layer coming out of the ground, that is, the trunk of the new vine, is considerably larger in diameter than the portion of the layer going into the ground, the layer can be cut from the parent vine. This is usually about 3-4 years after the layer is planted. A new vine will have been established. When in doubt, don't rush severing a layer from the parent vine. Another use for layering occurs when a vine has no suckering capability near the ground to produce trunk renewal canes. In such instances a so-called “whip layer” can be looped around and placed at the base of the vine from which it originated. It is managed the same as a normal layer.

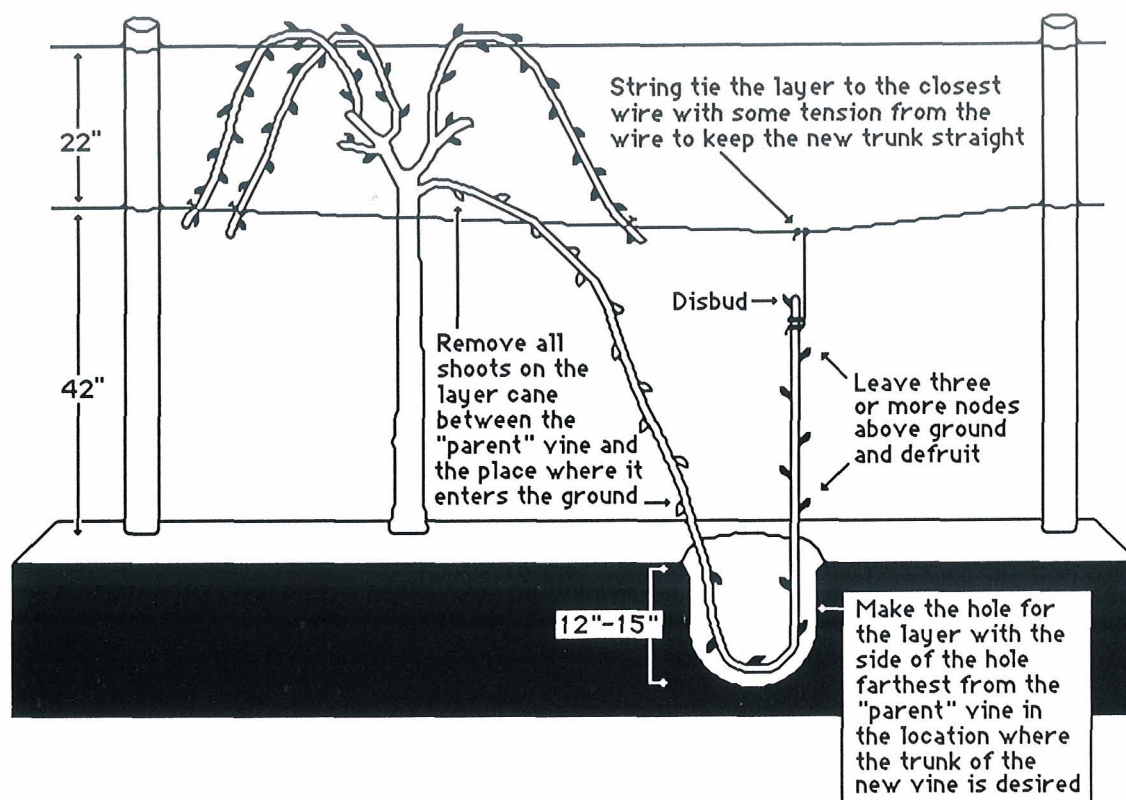


Figure 5 - A grapevine which is the source of a layer for filling in a vacant, adjacent vine space. The details of managing this layer are indicated.

Steps in Pruning

Pruners with experience don't begin the job with a specific set of steps in mind because the pruning procedure becomes habitual with experience. Nevertheless pruning is a systematic process, and therefore, it can be described in a series of steps or procedures. For those who might desire some guidance, the following list of steps for the pruning of Concord grapevines is offered. We'll begin with the assumption that the pruner is aware of the training system to be used.

Step 1 - Judge the size of the vine to be pruned by estimating the pounds of cane prunings on the vine.

Step 2 - For Concord vines being grown for table grapes, make a mental calculation of the number of nodes to be left on the vine using a balanced-pruning formula of $30 + 10$.

Step 3 - Look at the vine spaces on either side of the vine being pruned to determine if a layer is needed. If so, and if a long cane is available for this purpose, select and prune it to length. Tie it to the trellis, preferably with flagging tape for easy identification, and remove the brush from around it so it won't be damaged during the brush-pulling operation.

Step 4 - Determine if a trunk renewal cane is required (Figure 4). If so, and if one is available, prune it.

Step 5 - It is recommended that all shoots retained on trunk renewal canes and layers be defruited. However, if this is not practiced, subtract the node number which will ultimately be retained on a layer and/or a trunk renewal cane from the total number of nodes required on the vine.

Step 6 - Focusing on the renewal zone of the vine, locate and select the number of fruiting canes required for the desired node number. Locate half of the required canes on each half of the vine space.

Step 7 - After all fruiting canes have been selected and pruned, eliminate excess nodes on the vine. Begin by making pruning cuts just beyond the chosen fruiting canes. Then follow a path down (basal) each arm of the vine. When possible leave 1-2 node renewal spurs at desirable locations in the renewal zone.

Step 8 - Make additional pruning cuts on 2-year and older wood, which has already been cut from the vine, to facilitate the brush pulling operation.

Step 9 - For training systems, which free the vine entirely from the trellis and require complete retying in the spring, cut any string and/or twistem ties, which attach the vine to the trellis. Shake the vine momentarily and observe how it has been pruned. This shaking tends to reveal any parts of the vine, which were unintentionally left attached to the vine.

Step 10 - The above steps complete the normal pruning operation. However, if the vine is being used to "develop one's eye" for vine size, separate the canes pruned from the vine from older wood. Gather them into a bundle and weigh them. Compare this actual weight of cane prunings to your estimate. If too many nodes were retained in regard to the measured pruning weight, prune the excess nodes from the vine.

The Influence of Pruning

Pruning has a major impact on potential crop size. As pruning severity increases (fewer nodes are retained), yield decreases and fruit maturity increases. Other aspects of fruit quality of importance to the Concord table grape grower are cluster compactness and berry size. As pruning severity decreases, there is generally a modest decline in berry weight, that is, less than 10% (Kimball & Shaulis, 1958; Shaulis & Steel, 1969; Cawthon & Morris, 1977). However, a decrease in pruning severity tends to significantly reduce the number of berries per cluster. If one study, for example, a reduction in pruning severity from a 20 + 10 to a 65 + 10 pruning formula resulted in a 19% decline in the berry number per cluster (Kimball and Shaulis, 1958).

Summary and Recommendations

Pruning has a large influence on both the yield of Concord grapes as well as their quality. Concord vines which are managed for fresh fruit should be pruned to a 30 + 10 pruning formula. Fruiting canes should be chosen on the basis of rich color, short internode length

and large diameter. The use of large diameter canes is satisfactory as long as persistent lateral canes are spurred. Pruning severity has a relatively minor influence on berry size but it does significantly affect cluster compactness (berries per cluster).

TRAINING

Introduction

Training establishes a reproducible growth form for a grapevine. That is, vines are trained to a shape which can easily be maintained year after year. The second attribute of a training system is that it produces adequate numbers of high quality canes in the renewal zone. Training is extremely important to table grape production for it has a powerful influence over yield as well as fruit quality. Therefore, this topic will be discussed in some detail beginning with an historical review of those training systems which have been developed and used on native American varieties. This historical perspective provides not only an interesting reflection of our viticultural heritage, but more importantly, it provides insight into our current understanding and use of training systems for Concord grape production. We will also discuss the evolution of training systems, the influence of training on vine performance, the trends in commercial use of training systems for the Concord variety and finally, a recommendation for training vines for Concord table grape production.

The History of Training Native American Varieties

Grape growing began in the Chautauqua, Hudson Valley and Finger Lakes regions of New York about 1818, 1827 and 1830, respectively. At that time native American varieties such as Isabella and Catawba were trained with systems of European origin. Vines were typically

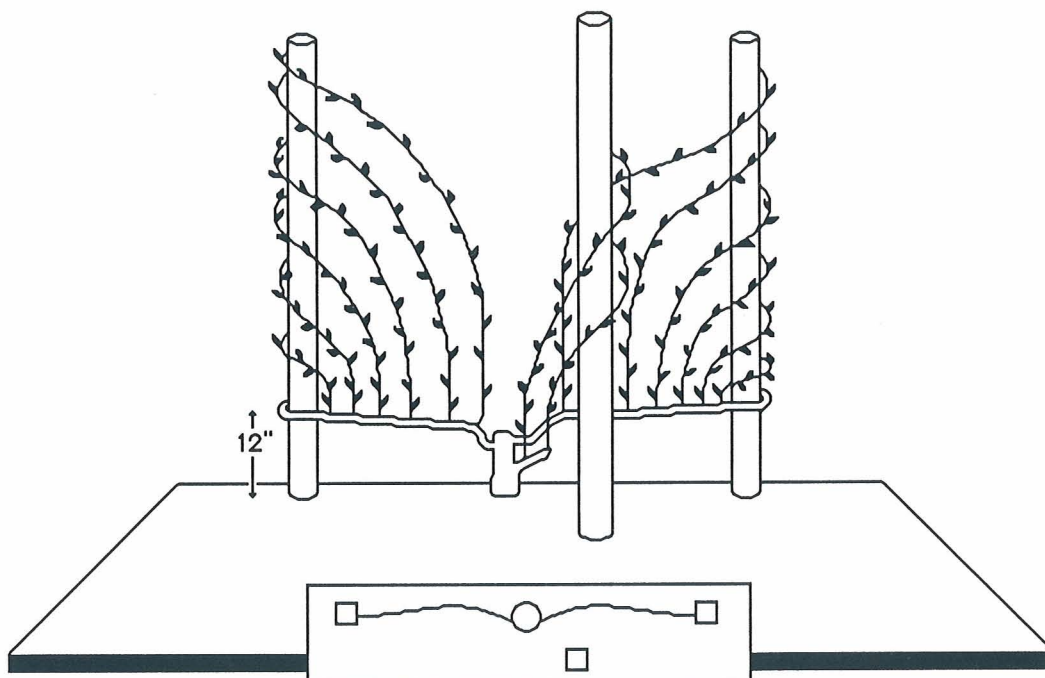


Figure 6 - A graphic representation of the type of training system used in the early 1800's to train native American varieties in New York State. The principles of this training system were of European origin.

pruned back to two 4-6 node canes, which originated within a few inches of the ground. (Figure 6) Each of these was tied to its own stake about 16 inches from the base of the vine. As shoots grew, they were tied up on the stakes. Renewal spurs were retained basal to these fruiting spurs. Shoots from these renewal spurs were tied to a third stake, which was located next to the trunk of the vine.

With this “European” training system, the shoots, which originated from the renewal spurs, were the source of next year’s fruiting canes. Therefore, the renewal zone of this training system was located just a few inches from the ground.

Native American varieties were not well suited to this European training system, and therefore, new training systems were developed. Several of these early American training systems are categorized as “upright systems” because like their ancestral European systems, they require shoots to be tied upward as they grow from a renewal zone located relatively low on the trellis.

The Horizontal Arm Spur system was the first American training system to be used extensively. It is established by tying a cane on a low wire (about 18" above ground) in each direction from the trunk (Figure 7). Shoots from these canes are then tied up to wires higher on the trellis. In subsequent years the cordons (horizontal arms), which develop from the canes on the low wire, are retained. The upright growing canes, which originate from these cordons are pruned back to two-bud spurs. Today this system would be described as a spur-pruned, low wire, bilateral cordon.

The Horizontal Arm Spur system became modified into the High Renewal system, which uses long fruiting canes (Figure 8) instead of a cordon with spurs. One cane is tied in each direction along a low wire, which is located from 18" to 30" above ground. The name High Renewal refers to the location of the renewal zone of this training system, which is considerably higher on the trellis than previously used European systems. By today’s standards, however, a renewal zone which is located 18"-30" above the ground, would be considered “low renewal!” High Renewal is also an “upright system” because it requires

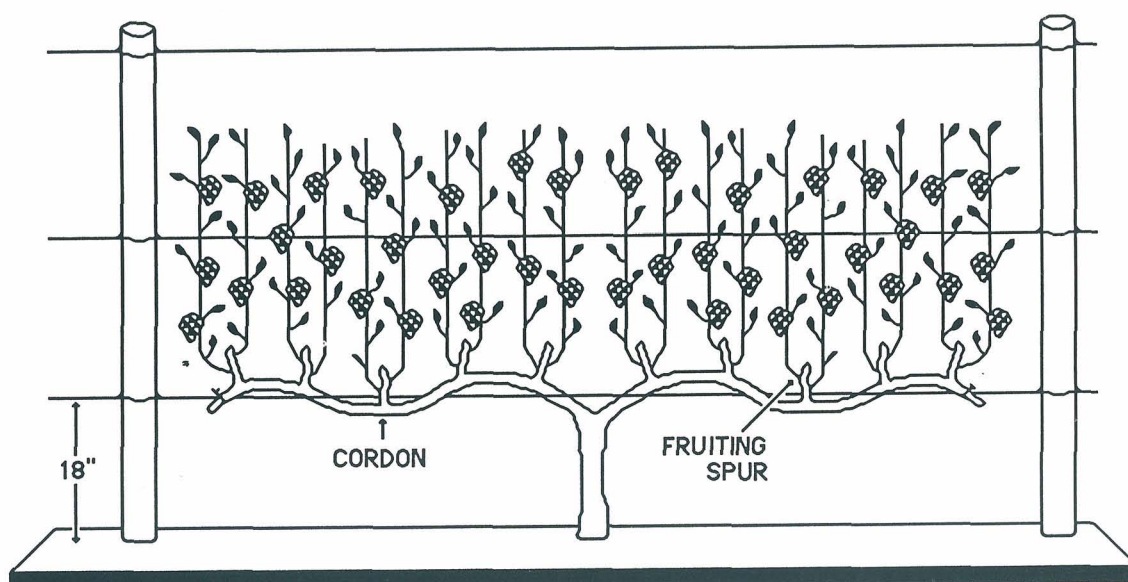


Figure 7 - A graphic representation of the Horizontal Arm Spur training system, which involves the use of a cordon on a low wire with fruiting spurs along that cordon.

tying the shoots to the upper wires on the trellis. The High Renewal system, also called the Keuka High Renewal system, was used extensively in both the Finger Lakes and in western New York for many decades. Today a modified Keuka High Renewal system is still used in many French-American hybrid vineyards in the Finger Lakes region.

The Chautauqua system, another of the “upright systems”, has a form similar to the Horizontal Arm Spur system with a cordon being established on a low wire about 18-20" above ground. However, instead of developing fruiting spurs on the cordons as with the Horizontal Arm Spur system, the Chautauqua system retains long fruiting canes. These are tied up to one or two wires higher on the trellis (Figure 9). Renewal spurs of 2-3 nodes are also retained on the cordons.

While these “upright systems” were being used extensively in the Finger Lakes and western New York grape growing regions, the training of grapevines in the Hudson Valley region was evolving in another direction. Today most growers of native American varieties recognize the name Kniffin because several Kniffin training systems are currently in wide commercial use. These Kniffin systems originated as a part of the rich Hudson Valley grape growing heritage. It began about 1852 with a fortuitous accident in the vineyard of William Kniffin, who was a stone mason by trade. As the story is reported, a vine in Kniffin’s vineyard was crushed by a fallen limb of an apple tree. At harvest the fruit on this injured vine was noted for its large, handsome appearance. Kniffin attributed this result to the accidental horizontal positioning of the canes. Today, we might conjecture whether or not the sizing and maturing of the fruit might have been influenced by partial girdling or breakage of canes from the accident and/or better sunlight exposure of the fruit on this “crushed” vine. Regardless of the actual cause of the improved fruit quality, within two years a training system which was

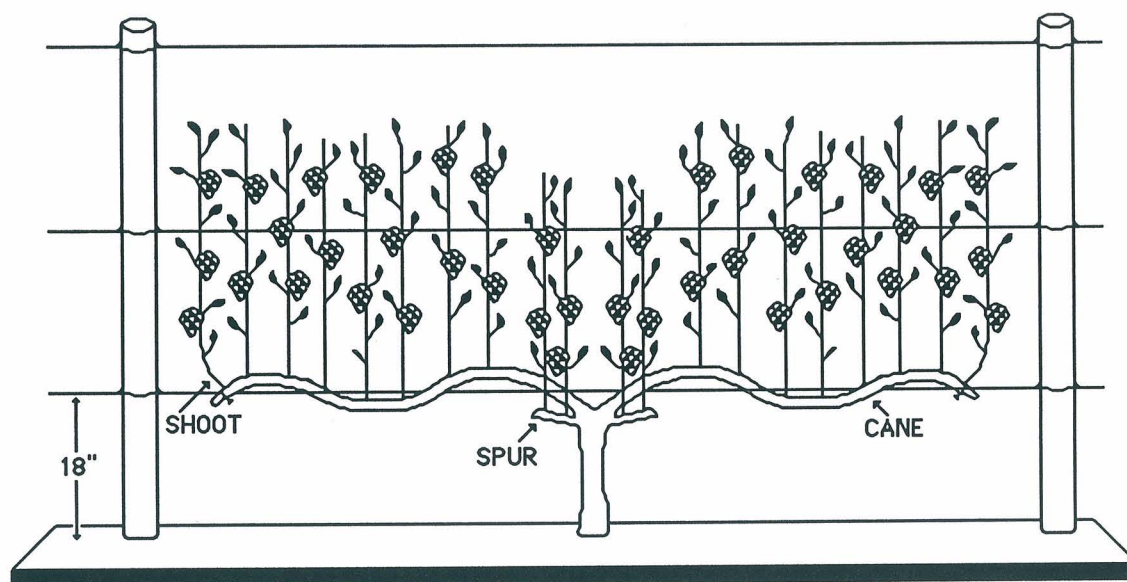


Figure 8 - A graphic representation of the High Renewal training system which involves the placement of fruiting canes on a low wire on the trellis. Shoots from renewal spurs placed basal to the fruiting canes are the source of the following year's fruiting canes.

first called the True Kniffin system, then the Four- Cane Kniffin system and now the Four-Arm Kniffin system was already being used by several neighboring grape growers. As this system was first used, two trellis wires were placed about 42" and 64" above ground (Figure 10). Canes were tied out in each direction on the two wires and renewal spurs were retained basal to these four canes. Four-Cane Kniffin was truly revolutionary because it utilized renewal zones much higher on the trellis than previously used training systems. Therefore, the shoots and fruit could be allowed to hang downward rather than being tied upward. It was the first of the so-called "drooping systems".

Several other training systems evolved from the Four-Cane Kniffin system. Growers discovered that at times the vigor of vines justified retaining more nodes than could be supplied by four canes. Therefore, Six, (Figure 11) Eight and even Ten-Cane Kniffin systems evolved.

While using the Four-Cane Kniffin system, it was also observed that nodes on canes located on the upper wire of the trellis produced more and better fruit than those on the lower wire. Therefore, a trend developed, which favored the upper canes by putting more nodes on them than the canes on the lower wire. This eventually led to extending the length of the canes on the upper wire to 9-15 nodes and total abandonment of the lower canes. As it was first conceived, this modified system used two long canes, which originated at or slightly above the top wire and were then tied in an arch shape to the lower wire (Figure 12). This system was first called the Two-Cane Kniffin. It wasn't long, however, before as many as five canes per vine were being used and later this system was called the Umbrella Kniffin. Unfortunately, today's use of the Umbrella Kniffin system (Figure 13) generally involves a shaded renewal zone from 6" to 15" below the top wire rather than near the top wire as the system was originally conceived.

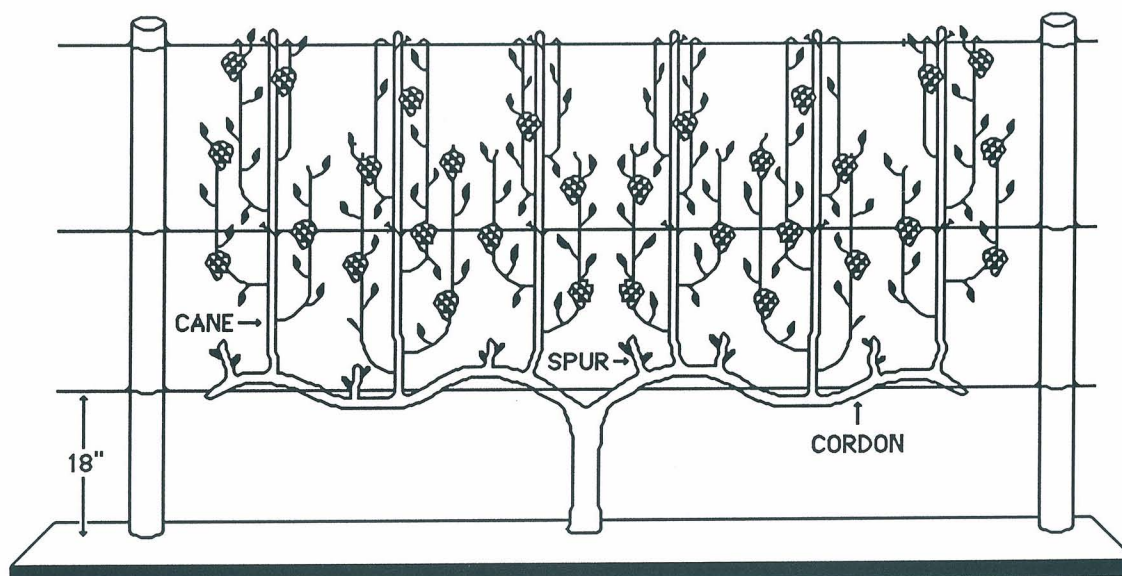


Figure 9 - A graphic representation of the Chautauqua system which involves a cordon on a low wire on which long fruiting canes are located and tied up on the trellis. Two-bud renewal spurs are retained on the cordon among the fruiting canes.

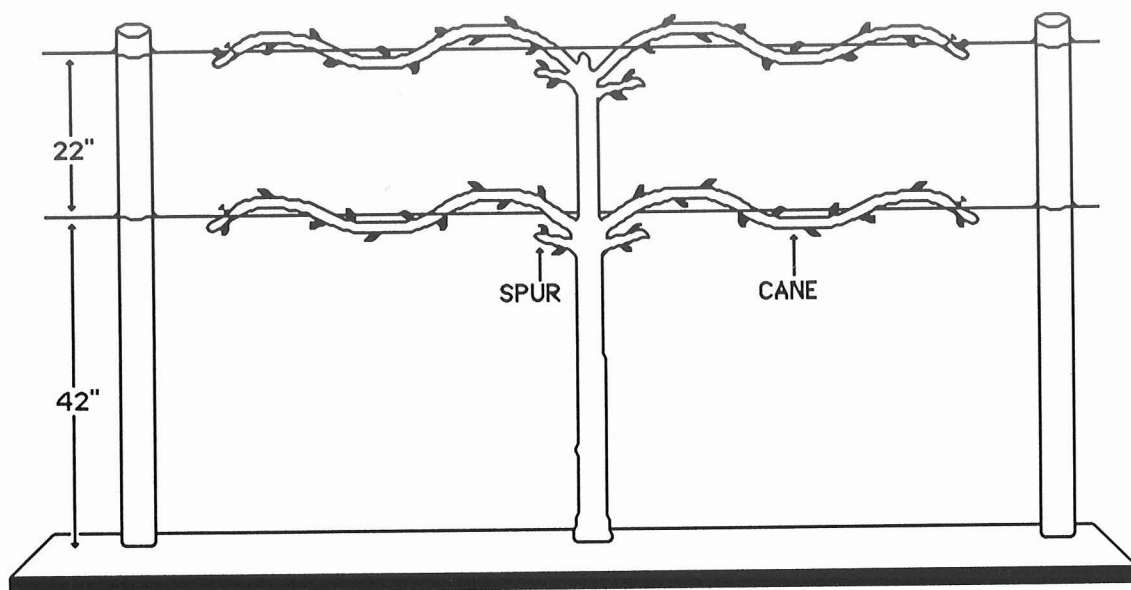


Figure 10 - A graphic representation of the original form of the Four-Cane Kniffin training system.

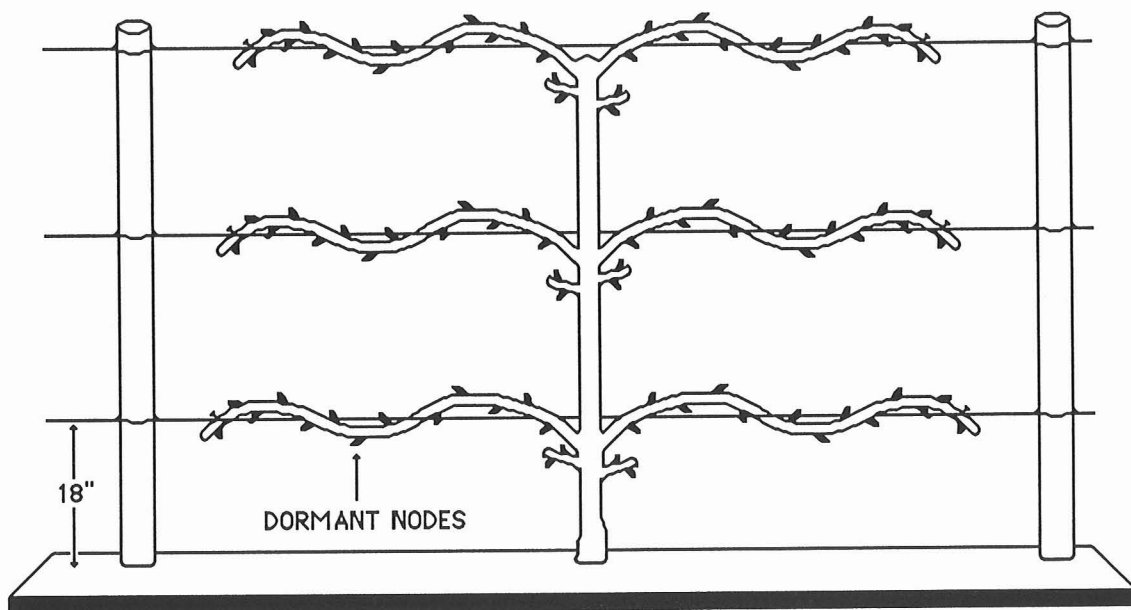


Figure 11 - A graphic representation of a Six-Cane Kniffin training system. This training system is widely used today in Canadian viticulture.

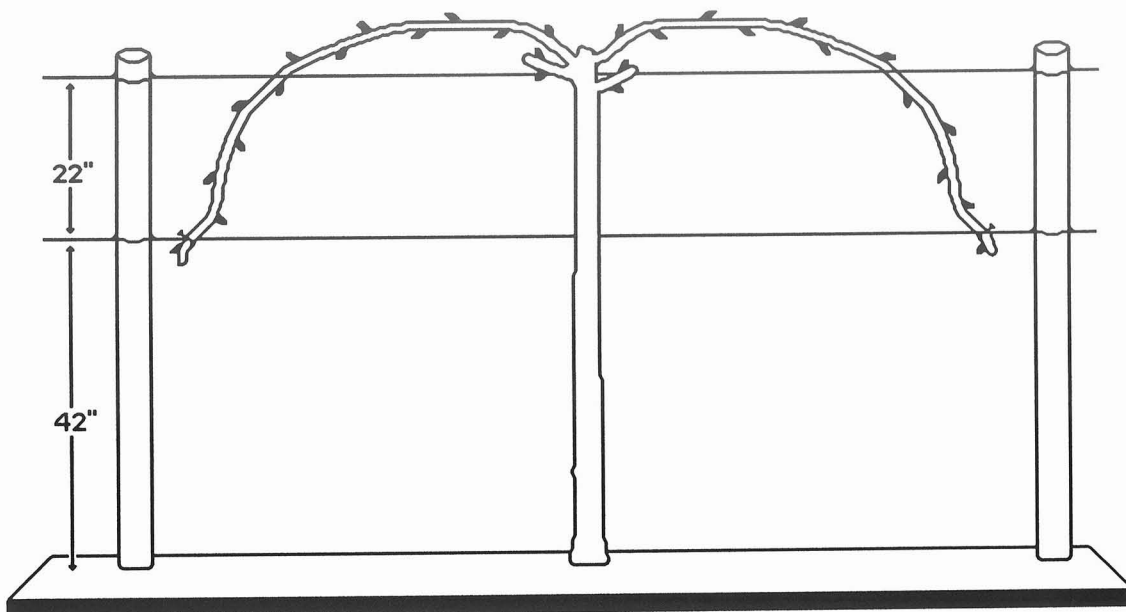


Figure 12 - A graphic representation of the original form of the Umbrella-Kniffin training system which utilized two long canes originating above the top wire of the trellis.

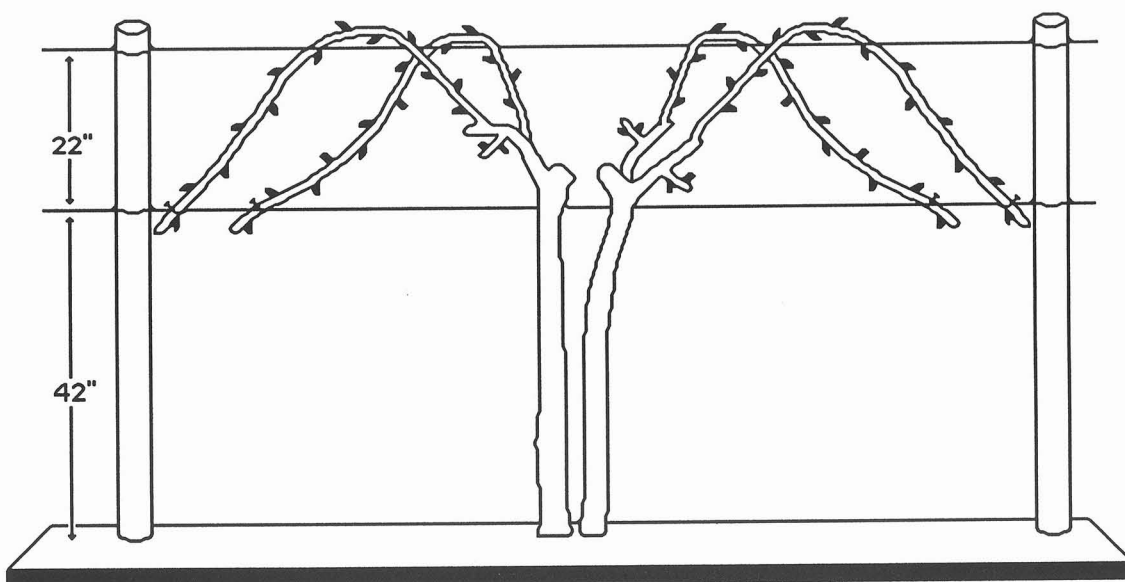


Figure 13 - A graphic representation of the current use of the Umbrella-Kniffin training system with a double-trunk and a head region 6 to 15 inches below the top wire of the trellis.

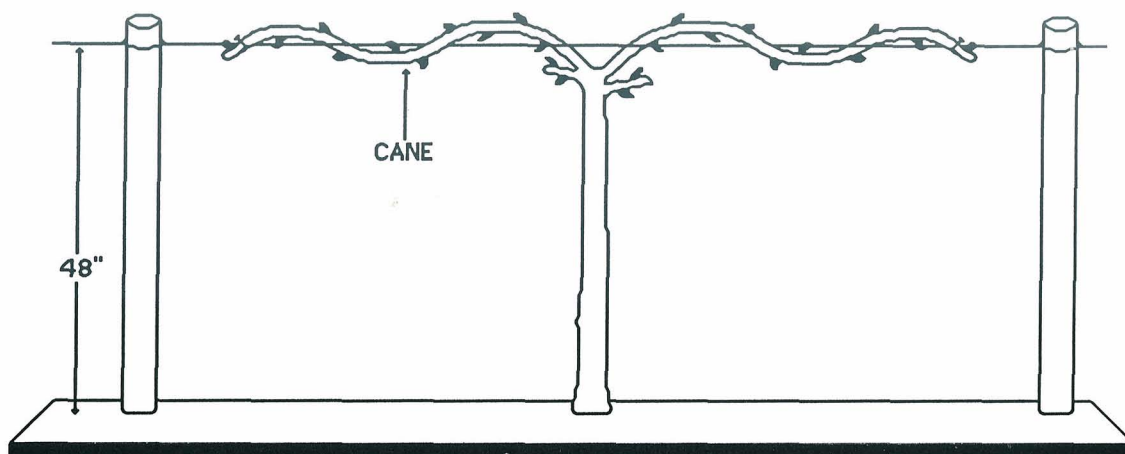


Figure 14 - A graphic representation of a One-wire Kniffin training system that was used in New York viticulture in the 1800's.

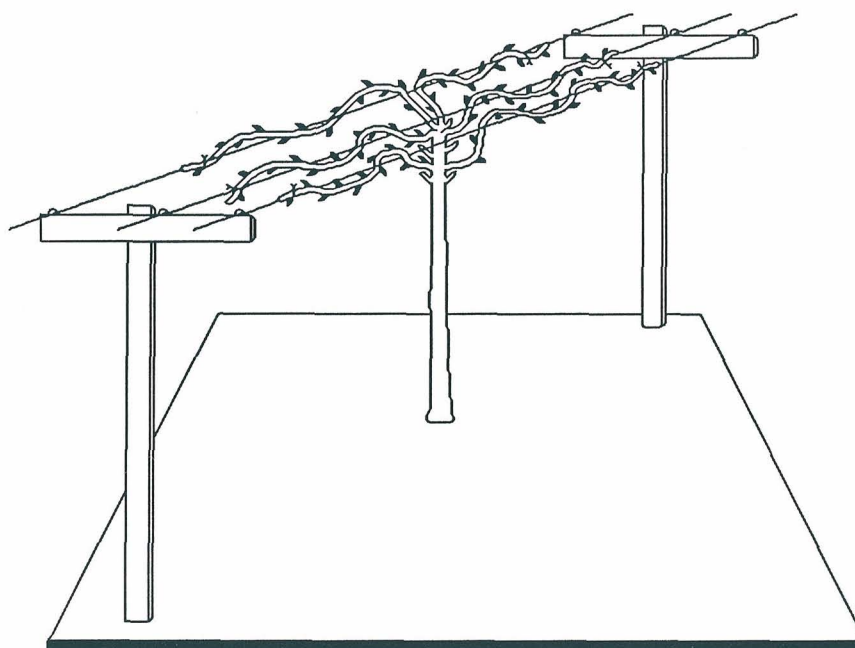


Figure 15 - A graphic representation of the Arbor-Kniffin training system used in New York viticulture in the 1800's. This three-dimensional training system uses up to six canes tied out three wires at the top of a T-shaped trellis.

Another training system devised in the 19th Century was the Low Kniffin or One-Wire Kniffin. This uses a trellis three to four feet high with one wire at the top (Figure 14). Two canes of 10-12 nodes each are tied out the wire, one in each direction from the trunk. Apparently, this system was never used extensively, perhaps because it severely limits the number of nodes per vine, which can be retained at pruning.

There were also three dimensional trellis and training systems developed for native American varieties in the 19th Century. The Overhead Kniffin or Arbor Kniffin system uses three foot cross arms placed at the top of six foot posts (Figure 15). Rows are spaced nine feet apart. Posts and vines (there is a post between each vine) are placed 12 feet apart. Three wires are strung along the middle and outsides of the cross arms. Depending upon the number of nodes desired, five or six canes are retained and tied out these wires.

The Cross-Wire system was used by some growers in the Hudson Valley near Marlboro. It involves individually staked vines placed eight feet apart in each direction. Wires are strung along the top of the posts in two directions perpendicular to each other to form a grid. Canes are then tied to these wires in all four directions from the trunk (Figure 16). Although the fruit hangs well with this arrangement, the limited use of this system was probably due to the inability to access the vineyard with machinery. This system is functionally similar to the overhead arbors used extensively today for table grape production in Japan.

The Munson system, which was developed by and named after the famous American viticulturist T.V. Munson, was originally designed with two slanted posts set in the same hole. A wire is strung between these posts near their tops (Figure 17). These cross wires support a wire running the length of the trellis a few inches lower than the other wires which run the length of the trellis along the tops of the stakes. Two to four fruiting canes are tied out the middle wire. From the renewal zone just below the middle wire, two to four shoots

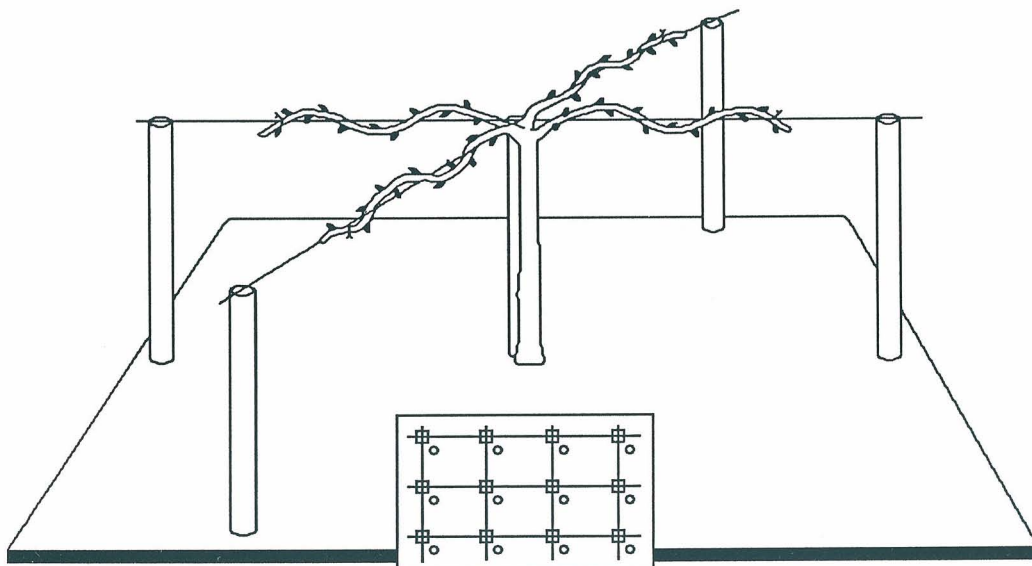


Figure 16 - A graphic representation of a three dimensional Cross-wire training system which was used in New York viticulture in the 1800's.

are selected, defruited and trained along the middle wire to provide the following year's fruiting canes.

Later, the trellis construction for this training system became modified so that posts are set 4 1/2 feet high with a 3/8" hole bored through each post at four feet above ground (Figure 18). The middle wire runs through these holes and supports a notched 24" cross arm, which is then wired to the post. The outer wires are attached to the top ends of the 2" X 4" X 24" cross arms. The vine is trained as described previously.

A major advantage of these three-dimensional training systems is that clusters hang free from entanglement in shoots and tendrils.

All the training systems described thus far were developed in the 19th century. The Hudson River Umbrella system had already been in commercial use for some time when it was described by Gladwin in 1919. Therefore, it too probably had a 19th century origin. This system utilizes cordons on the top wire of the trellis from which fruiting canes either hang down or are tied down to a lower wire (Figure 19). In recent years this system has also been called a Single Curtain system or No-Tie system. The latter name has been applied when relatively short fruiting canes of 5 nodes or less are used or when longer canes are left untied.

20th Century Research on Training Systems

There were essentially no new training systems of any significance developed for native American varieties in the first half of the 20th Century! Training research at that time was concerned with the performance of those training systems which had been developed in the 19th Century. Keffer (1906) was the first to gather information and suggest that training systems other than Chautauqua and Keuka High Renewal were superior for the growth of Concord. Several researchers including Gladwin (1919), Colby (1925), Partridge (1925),

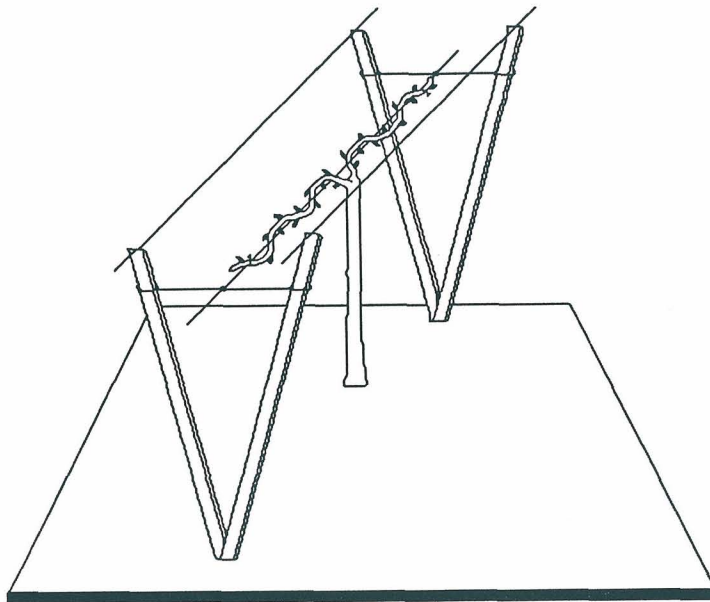


Figure 17 - A graphic representation of the original design for the three-dimensional Munson training system. The two posts were used to form a "V" which supported a middle-wire about six inches below two outer wires fastened to the top of the posts.

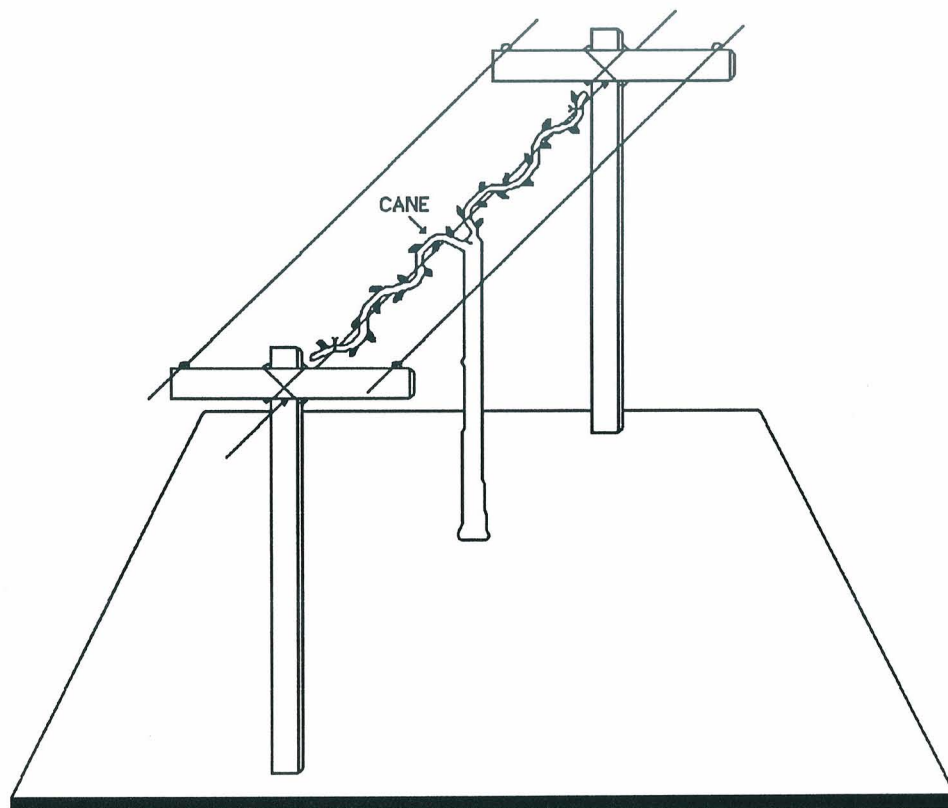


Figure 18 - A graphic representation of a revised Munson training system. A cross-arm is fastened to the top of each post to support the outer catch wires.

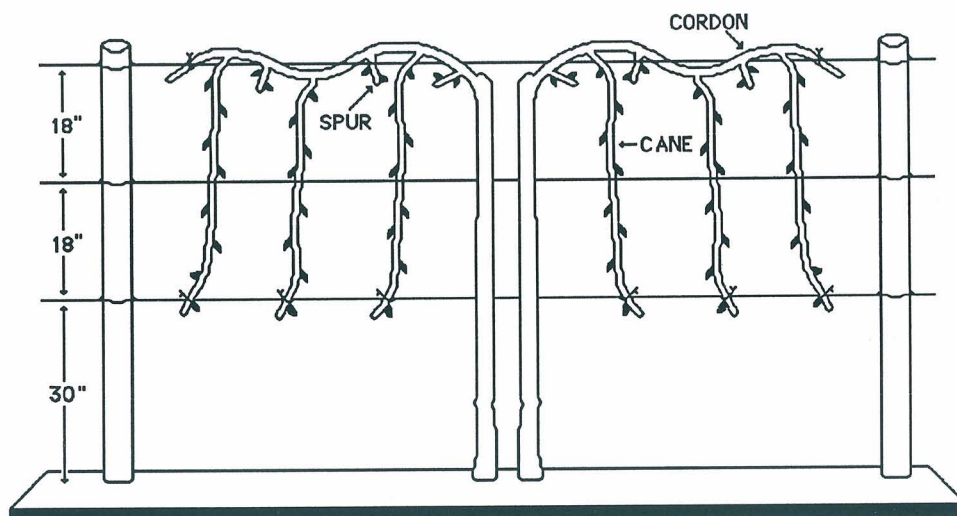


Figure 19 - A graphic representation of the Hudson River Umbrella training system with the use of double trunking. The canes originating from a cordon on the top wire are tied to a lower wire. Renewal spurs are placed on the cordon among the fruiting canes.

Faurot (1933) and Cooper and Vaile (1939) recommended the Four-Cane Kniffin system (also called Single-stem Kniffin at the time) as the best overall training system for Concord vines. Colby (1929) further concluded that on vigorous vines the use of Six-Cane Kniffin was superior to Four-Cane Kniffin because it permitted retention of more fruiting canes.

Much research effort on Concord was spent in the early part of this century measuring the fruitfulness of node positions on fruiting canes. It wasn't until the pioneering work of Shaulis and his co-workers in the 1950's that the influence of sunlight exposure on bud fruitfulness became apparent. This seems a basic viticultural principle today. However, not too many decades ago it was believed that the fruitfulness of a node on a Concord cane was determined by its location on the cane. Today we understand that node fruitfulness depends upon on the environment in which that node developed in the previous year. Shaulis and his associates

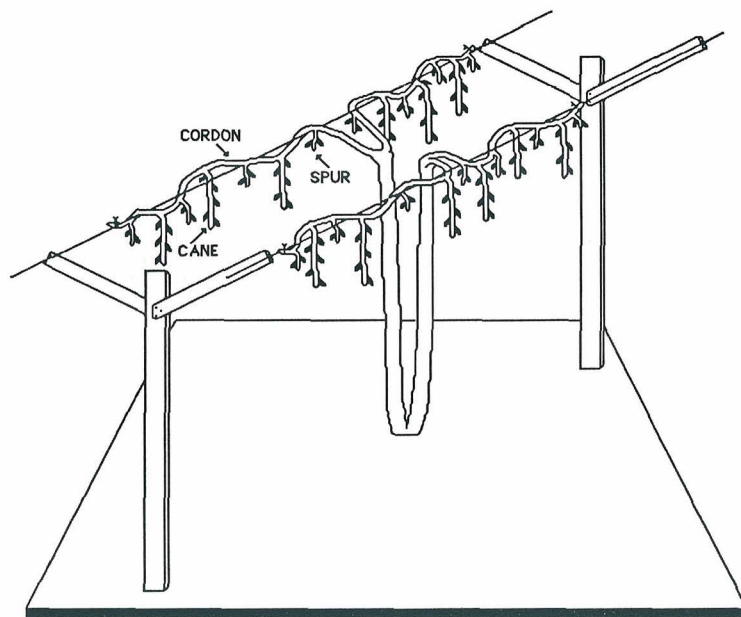


Figure 20 - A graphic representation of the Geneva Double Curtain training system which establishes cordons on wires which are offset from the central plane of the trellis.

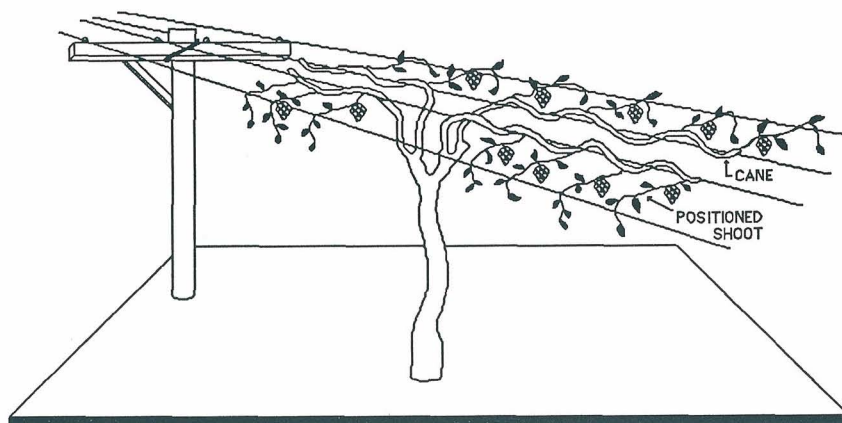


Figure 21 - A graphic representation of a Modified-Munson training system. Fruiting canes are tied to inner wires on the cross-arm and shoots are then positioned over the outer wires.

devised the viticultural practice of shoot positioning, which minimizes the shading of shoots by each other and also reduces the shading of fruit. They applied this procedure to the Hudson River Umbrella training system and they also developed the Geneva Double Curtain training system, which allows minimal shading of the shoots and fruit. This three-dimensional training system requires metal or wooden arms to be attached to the trellis posts (Figure 20). These arms hold wires two feet on either side of the central, vertical plane of the trellis. Canes are tied out these wires to become cordons. Canes, which develop from these cordons, are typically pruned to a length of 5-7 nodes. 1-2 node spurs are also retained on the cordon for renewal purposes. From about mid-June to early July the bases of these shoots are positioned to prevent shading of the basal nodes. Given adequate vine size, this training system has provided the highest yields of quality fruit of any training system yet devised for Concord grapevines planted at standard row spacings.

Commercial Trends

Hedrick (1907) wrote about a Finger Lakes grape grower as follows: "In 1853 a commercial vineyard was set out by Andrew Reisinger, a German vine-dresser, consisting of two acres of Isabella and Catawba at Harmonyville in the Town of Pulteney. Reisinger trained, pruned and tilled his vines, operations unheard of before in the district, and was rewarded with crops and profits which stimulated grape culture in his and nearby neighborhoods."

Therefore, it appears that little attention was given to the training of vines during the first two or three decades of grape growing in New York and that sincere interest in the training of grapevines in New York did not begin until the latter half of the 19th century. However, by 1900 New York's Chautauqua, Finger Lakes and Hudson Valley grape growing districts each had their own predominant training systems, which were the Chautauqua, the High Renewal and the Four Cane Kniffin systems, respectively.

Although the popularity of Four-Cane Kniffin did grow somewhat in commercial use during first several decades of the 20th Century, tradition was apparently hard to overcome. Scoville reported in 1933 that 50% of Finger Lakes vineyards still used High Renewal training and Shaulis et al. (1953) stated that High Renewal was still the dominant training system in the Finger Lakes in 1946. New York growers were slow to adopt not only the Four-Cane Kniffin but also the Umbrella Kniffin system. This lag occurred despite the fact that research evidence, which documented the superiority of Umbrella Kniffin over other systems, had been mounting for decades.

This lag in the commercial adoption of training system technology might partially be explained by the occurrence of relatively small vine size in many vineyards in the first half of the 20th Century. Differences in the performance of training systems which result in shading of shoots and fruit, are less pronounced with small vines. For example, Gladwin (1919) used vines averaging 1.5 lbs. of pruning weight and found no significant differences in yield among several training systems. Shaulis and Oberle (1953) conducted research on vines with 1 1/2 - 2 lbs. of pruning weight and found no significant yield differences when comparing the Umbrella Kniffin, Four-Cane Kniffin, and High Renewal training systems.

The Evolution of Training Systems

With the benefit of today's viticultural insight, it is useful to look back upon more than a century of New York viticultural heritage to see a very interesting evolutionary trend in the

use of training systems. The renewal zones of these various training systems show a distinct trend towards their placement at increasingly higher, more sunlight-exposed positions on the trellis. It began with the European approach to training, which placed the renewal zone within six inches of the ground. The Horizontal Arm Spur and High Renewal systems moved the renewal zone up to 16"-30" above ground. Subsequently, there was the Four-Cane Kniffin system with a renewal zone 42"-68" above ground.



Figure 22 - Concord table grapes at harvest which were produced on a Modified-Munson training system.

That was followed by the original Umbrella Kniffin system, which put the renewal zone right at the top of the trellis. From there sunlight exposure of the renewal zone could only be improved by shoot positioning or canopy diversion. The HRU and GDC systems utilized those changes.

This trend is a testimony to the importance of sunlight exposure of renewal zones in the temperate climate viticulture of New York. A recognition of this New York viticultural heritage can help to avoid repeating the use of the inferior training systems in the future. A grower's choice of a training system has become an increasingly important factor for determining the productivity of his Concord vineyard. The size of vines in New York vineyards has increased significantly in recent decades as a result of improved weed control, fertilization and pest control practices. With this increase in vine size, the superiority of training systems which have their renewal zones high on the trellis and well exposed to sunlight has become apparent. Umbrella Kniffin has ranked as the most widely used training system in New York viticulture for more than three decades. During that time use of the Hudson River Umbrella and Geneva Double Curtain systems have grown in popularity, especially in the Chautauqua County area. The adoption of the HRU and GDC training systems has occurred not only because of their superiority in regard to sunlight exposure of the renewal zone, but also because their horizontal cordons are compatible with efforts to mechanize the pruning of vines and reduce annual brush pulling and tying costs.

Current Developments

Some of the three-dimensional training systems, which were developed in the 19th century, afford a major hand-harvest advantage because they position clusters to hang free from entanglement with shoots and tendrils. However, at the time these systems were developed, they were managed without an appreciation of the importance of the sunlight exposure of fruit and the shoots in the renewal zone. The dense canopies that piled up on top of these three-dimensional training systems actually led to shaded renewal zones, mediocre yields and poor fruit quality. Today, however, the practice of shoot positioning affords a new outlook on

merits of three-dimensional training systems. A combination of three-dimensional training plus shoot positioning can situate fruit for easy hand harvest while at the same time insuring good sunlight exposure of both the fruit and the shoots in the renewal zone (Figure 21). Trials of such a combination involving a modified-Munson system have been in progress for two years (Figure 22). Thus far this new experimental approach to training Concord table grapes has produced fruit which ripens early and uniformly, and shows indications of a higher percentage fresh fruit utilization and greater picking efficiency than with other commonly-used training systems. Several variations of this modified-Munson training system are now under evaluation, some of which appear to be compatible with the typical mechanical harvesting equipment now used in the New York grape industry. Growers interested in this current research should contact Cornell Cooperative Extension for further information.

Mechanical shoot positioning research, which aims to greatly reduce the amount of labor required for shoot positioning, is another area currently showing progress. Advances in mechanical shoot positioning would likely hasten the rate of commercial adoption of the HRU and GDC training systems.

Up to this point all discussion on training systems has been limited to viticultural concerns. However, lack of harvest labor, which is ultimately caused by hand harvest inefficiency and resulting low wages, is the principal limitation to the expansion of New York's Concord table grape industry. Therefore, growers should consider a training system for their vines with regard for hand harvest efficiency as well as yield and fruit quality.

Recommendations

When vine size is small, 1 1/2 lbs. of cane prunings or less for vines spaced 7-8 feet apart, viticultural practices to increase vine size (Table 3) are more important to the economics of the vineyard than the choice of a training system. For medium to large vines, growers of Concord table grapes in the relatively cool climate of New York should utilize a training system which utilizes shoot positioning to (a) expose fruit to sunlight, (b) obtain the best possible exposure of the renewal zone and (c) enhance hand harvest efficiency. Hudson River Umbrella and Geneva Double Curtain are the currently recommended systems in this category. The Modified-Munson system, which fits into this category, is presently under investigation and not recommended at this time.

The Umbrella Kniffin training system is not recommended for production of Concord table grapes because it produces fruit which is of inferior quality and is more difficult to harvest than with the recommended training systems. Nevertheless, if a grower insists on using this training system, then it should be utilized in a manner similar to its original form, that is, with the renewal zone close to the top wire and with relatively long fruiting canes. (Figure 12).

VINEYARD NUTRITION

High yields and high fruit quality can only be obtained when vine nutrition is not limiting. Grapevines require 16 nutrients for their growth. Nine of them are called macronutrients

because they are required in relatively large concentrations. They are: carbon, hydrogen, oxygen, nitrogen, potassium, phosphorous, magnesium, calcium and sulfur. A second group of seven nutrients are called micronutrients because they are required only in relatively small concentrations in terms of parts per million of the dry weight of vine tissues. This group includes: manganese, zinc, iron, boron, molybdenum, chlorine and copper. Fortunately, only six of these nutrients have been shown to be deficient in New York Concord vineyards. These six include three macronutrients, (nitrogen, potassium and magnesium) and three micronutrients, (iron, manganese and boron). To further simplify matters, two of these six nutrients, iron and manganese, are only of occasional, significant commercial concern in New York Concord vineyards.

The impact of manganese deficiency on Concord grapevines is concerned with leaf integrity. Therefore, if a grower familiarizes himself with the leaf symptoms of manganese deficiency (Plate 1a), he will be adequately prepared to identify a problem in his vineyard which is caused by a deficiency of this nutrient. If such a problem occurs, he should consult Cornell Cooperative Extension for remedial measures.

Iron deficiency affects Concord grapevines in some New York vineyards. This problem typically occurs when a vineyard has been planted on a high pH soil. It is further aggravated by poor internal drainage of the soil. Although various foliar sprays and improved drainage of the soil can help to alleviate the iron chlorosis of the leaves (Plate 1b), such corrections typically do not significantly alter the performance of vines. Therefore, the avoidance of high pH, poorly drained soils when planting a Concord vineyard and the use of iron efficient rootstocks are the only practical means of avoiding problems of iron deficiency in New York Concord vineyards.

This leaves only four nutrients which are of common concern to New York Concord grape growers. Therefore, we will now review nitrogen, potassium, magnesium, and boron and discuss (a) their influence on vine performance, (b) appropriate methods of determining the adequacy of their supply and (c) fertilization practices for correcting deficiencies in their supply.

Nitrogen

- **Influence on Vine Performance** - Nitrogen is a growth stimulant. Growers correctly associate good vine size development with an adequate nitrogen supply. However, nitrogen adequacy is only one of the necessary conditions for good growth of vines. Other factors, which can stress a vine and influence the development of vine size include diseases, other nutrient levels, water supply (as influenced by vineyard floor management) and cropping level.
- **Determination of Adequacy** - Despite the fact that nitrogen is an important vine nutrient, petiole tests are unfortunately of limited value in diagnosing vineyard nitrogen status. Shaulis & Kimball (1956) and Benson et al. (1957) indicated that bloom time petiole tests of about 1.6% nitrogen or more were associated with highly productive Concord vineyards. Nitrogen petiole levels typically drop during the postbloom portion of the growing season so that by the time fall petiole tests are taken for the purpose of determining vineyard potassium requirements, a nitrogen value as low as 0.8% is normal. Only fall nitrogen petiole readings

less than 0.6% or greater than 1.2% would suggest a review of the nitrogen fertilization program.

However, even a nitrogen petiole test value of 0.6% or less in autumn tests does not of itself warrant increasing the rate of nitrogen fertilization. Growers should also rely upon vine size, fall leaf color and nitrogen fertilization history to determine the desired level of vineyard nitrogen fertilization.

The optimum vine size for Concord vines on two dimensional training systems is about 0.4 lbs. of cane prunings per foot of row (9 foot row spacing). Therefore, for vines typically spaced 7-8 feet apart, the rate of nitrogen fertilization should remain the same, or be decreased depending upon whether the vine size is about 3 lbs. or exceeds 3 lbs. of cane prunings per vine, respectively. For vines with less than 3 lbs. of cane prunings, all factors influencing the development of vine size including nitrogen fertilization should be reviewed.

- **Fertilization Practices** - Although some New York Concord vineyards require no nitrogen fertilization, most of them do to sustain high yields. When no nitrogen fertilizer history is available and when vines appear to be of optimum size in a mature vineyard, an application of 60 pounds of actual nitrogen per acre of vineyard is an average maintenance level of fertilization. If vine size is smaller than optimum and other factors do not appear to be responsible, then the fertilizer rate should be increased to a maximum of 100 lbs. of actual N (120 lbs. actual N for vines trained GDC) on those portions of the vineyard, where an increase in vine size is desired. On the other hand, if vine size is excessive, reduce nitrogen rates to 0-30 pounds actual nitrogen.

Ammonium nitrate (33% analysis) is the most commonly used nitrogen fertilizer in New York vineyards. However, other types of nitrogen fertilizers can be used. A grower can make his choice of nitrogen fertilizer based on the cost per pound of actual N, the ease of application of the material chosen and the risk of loss of nitrogen from volatilization. Nitrogen fertilizers should be broadcast applied about two weeks before the start of vine growth for maximum growth-stimulating benefit. Where root distribution may be limiting or where there is permanent sod, a banded application under the trellis is recommended. Dividing the nitrogen in two applications may be warranted in situations where oxidant stipple causes significant leaf deterioration.

Potassium

- **Influence on Vine Performance** - Slight deficiencies of this nutrient are important. They are indicated by the development of a marginal leaf chlorosis of leaves (Plate 1c), which becomes necrotic as the deficiency becomes more severe. As the deficiency becomes more acute, the entire leaf blade becomes scorched. Other manifestations of potassium deficiency include: (a) shoot stunting, (b) a reduction in the size of berries, (c) shelling of berries from clusters as the time for harvest approaches, (d) delayed and/or uneven ripening of fruit and (e) under conditions of severe deficiency, total bareness of the vine. Another symptom of potassium deficiency in grapevines is called black leaf (Plate 1d). Under conditions of heavy cropping the upper sides of Concord leaves can exhibit potassium deficiency by developing a dark blue-purple color. Although this symptom does often indicate that potassium may be

becoming limiting and so signal the need for future additions, according to Shaulis (1961), the occurrence of the black leaf symptom without the presence of the leaf scorch symptom does not warrant corrective measures. Deficiencies of potassium on grapevines have also been associated with reduced winter hardiness of vine tissues and increased susceptibility to diseases.

Excessively high levels of potassium can induce magnesium deficiency in New York vineyards. Therefore, habitual annual applications of potassium fertilizers to New York Concord vineyards may not only be a waste of dollars, but also it may be harmful to vine performance as well as product quality.

- **Determination of Adequacy** - Fortunately there are reliable methods for monitoring the potassium nutrient status in New York Concord vineyards. Although potassium deficiency has no impact on vine performance unless and until leaf deficiency symptoms appear, even the slight development of leaf symptoms involving 2% of the leaf area may be associated with as much as a 20% reduction in shoot growth and yield (Shaulis, 1961). Therefore, the use of petiole tests is highly recommended to avoid any possible influence of potassium deficiency on vine performance. Such tests should be taken at least 70 days after the end of bloom and after the beginning of fruit ripening and color development. Leaves showing potassium deficiency symptoms contain 0.6% or less potassium. In order to prevent a deficient condition from developing it is suggested that growers maintain vineyards within the recommended range. (Table 4) Higher levels may induce magnesium deficiency.

When taking petiole tests for the purpose of determining potassium fertilization, the topography of the vineyard should be considered. Knoll areas are likely to be lower in potassium than dip areas. For example, when a Finger Lakes Concord vineyard was extensively petiole tested, the knoll areas averaged 1.61% potassium while the dip areas averaged 2.78% potassium. These data indicate adequate levels of potassium on the knoll areas and excessive potassium levels in the dip areas. In such situations knoll and dip areas should be monitored separately with petiole tests and fertilized accordingly.

- **Fertilization Practices** - Potassium fertilization has been a habitual fall vineyard practice in many New York vineyards. Such an approach can be monetarily wasteful as well as injurious to vines. For example, a petiole analysis survey of 134 Finger Lakes vineyards indicated that 107 of these vineyards (80%) had adequate potassium levels and would require no potassium fertilization for at least one or two years. Furthermore, 31 of these vineyards (23%) had excessive levels of potash, which might be capable of inducing magnesium deficiency.

The habitual application of potassium fertilizers to every vineyard, every year is unwarranted. Petiole testing together with monitoring for leaf deficiency symptoms is a reliable, cost effective method of determining the need for potassium.

Potassium fertilizers are often applied in the fall because this is a slack time in vineyard operations and because that is the time when harvest-period petiole tests are returned to growers. However, one need not wait until the fall to apply potassium when a deficiency is detected. Apply potash fertilizers any time during the year when a deficiency is found. A typical rate of application in these situations is 300 lbs. of actual potassium per acre. Subsequently, perform a harvest petiole test to accurately determine the amount of potassium fertilizer required to correct the deficiency.

Either of the two commonly available materials, muriate of potash (potassium chloride) or sulfate of potash (potassium sulfate) may be used. In reality, differences between these two materials in cost per ton and percent actual potassium make muriate of potash the better value. Research has shown that when potassium fertilizers are broadcast in a vineyard, less of this potassium remains available to grapevines when compared to banded applications under the trellis. Therefore, potash fertilizers should always be banded under the trellis.

Lastly, there is an abiding concern that heavy, springtime applications of muriate of potash in New York vineyards might induce chloride toxicity in grapevines. However, to date there has been no documentation that such instances have actually occurred.

Magnesium

- **Influence on Vine Performance** - Magnesium deficiency occurs relatively frequently in New York vineyards. Leaf deficiency symptoms can be described as a chlorosis of leaves, which occurs most intensively on the leaves at the base of shoots. Interveinal areas become chlorotic with blotchy, rusty-red necrotic spots. On some affected leaves, the margins of the leaves remain green while the chlorosis develops on the interior portion of the blade. (Plate 1e) As the symptoms become more prominent, leaves become increasingly necrotic (Plate 1f) and may fall from the vine.

Fortunately, the impact of magnesium deficiency on vines is limited to the integrity of stems and leaves. Unless this deficiency affects a substantial portion of a vine's leaf area, it is not likely to have a significant impact on vine performance. Shaulis (1961) measured no influence on vine yield when magnesium deficiency affected as much as 20% of the leaf surface.

- **Determination of Adequacy** - In addition to the leaf deficiency symptoms described above, harvest petiole tests provide a reliable method of determining magnesium adequacy in vineyards. (Table 4)

- **Fertilization Practices** - Because the principal impact of magnesium deficiency is on leaf integrity, the amount of leaf degradation can be used to determine the need for fertilization.

TABLE 4. Critical values and desired ranges of values for three nutrients of importance to Concord table grape production. Values are for harvest-period petiole tests of recently matured leaves.

Nutrient	Critical Values ¹	Desired Range ²
Potassium	0.6%	1.1% to 1.8%
Magnesium	0.25%	0.26 to 0.50%
Boron	30 ppm	31 to 50 ppm

1. This or lower values indicate a need for corrective measures.

2. A grower should strive to maintain his vineyard within this range of values.

If a vineyard inspection reveals extensive magnesium leaf deficiency symptoms, then several possibilities exist to alleviate the problem. The easiest, cheapest and most effective short term solution is to apply foliar sprays. Twenty pounds of magnesium sulfate (epsom salts) per 100 gallons of water can be applied in postbloom sprays. However, this approach may not permanently correct the problem. Soil applications of magnesium fertilizers include: magnesium sulfate (the fastest acting approach); sul-po-mag fertilizers (when potassium is also required), and dolomitic lime (for a low cost, long term adjustment of magnesium levels in a vineyard which can tolerate some liming). The desirability of each of these approaches can vary with a particular situation. Consult Cornell Cooperative Extension on this topic when necessary.

Boron

- **Influence on Vine Performance** - A grower of Concord table grapes should definitely be aware of the boron nutrition of his vineyard. Boron has a strong influence on fruit set. A deficiency of this nutrient results in dramatic reductions in the number of berries per cluster. Those berries which form on boron deficient vines tend to be highly variable in size (Plate 1g). Severe deficiencies will result in totally barren vines. Because cluster compactness and berry size are very important to the table grape grower, care should be taken to avoid even mild deficiencies of this nutrient. Other symptoms of inadequate boron availability are reduced shoot growth with short internodes and misshaped, cupped leaves, which have a mottled chlorosis (Plate 1h).

- **Determination of Adequacy** - Boron deficiency is most likely to occur in vineyard areas characterized by either eroded soils or excessively well drained soils low in organic matter. Growers should especially check vines in such areas for deficiency symptoms. Although bloom time petiole tests are the best means of diagnosing boron deficiency, petiole tests at harvest time are useful in screening vineyards for boron deficiency. A boron concentration of 20 ppm or less in a harvest petiole test indicates a definite need for boron fertilization.

Boron values between 21 ppm or 30 ppm in the fall warrant a closer look at the vineyard. In this case a second petiole test is useful when taken just prior to bloom and before any foliar boron sprays. When a vineyard has uneven growth, such as that caused by undulating topography, petioles for these bloom time petiole samples should be taken from the vines in eroded and/or knoll sections of the vineyard. The more uniform the growth is in a vineyard and the higher the boron petiole test value in the range from 21 ppm to 30 ppm, the less likely there will be a measurable response to boron fertilizer applications. Boron fertilizers should not be used when boron petiole test concentration exceeds 30 ppm. Indiscriminate use of boron fertilizers can result in toxicity problems for the vineyard.

- **Fertilization Practices** - The most reliable method of improving fruit set on boron deficient vines is to apply foliar sprays prior to bloom. When a need for boron fertilization is identified, one half pound of actual boron per acre should be sprayed on vines 10-14 days prior to the start of bloom and again at the start of bloom. These two sprays should be a minimum

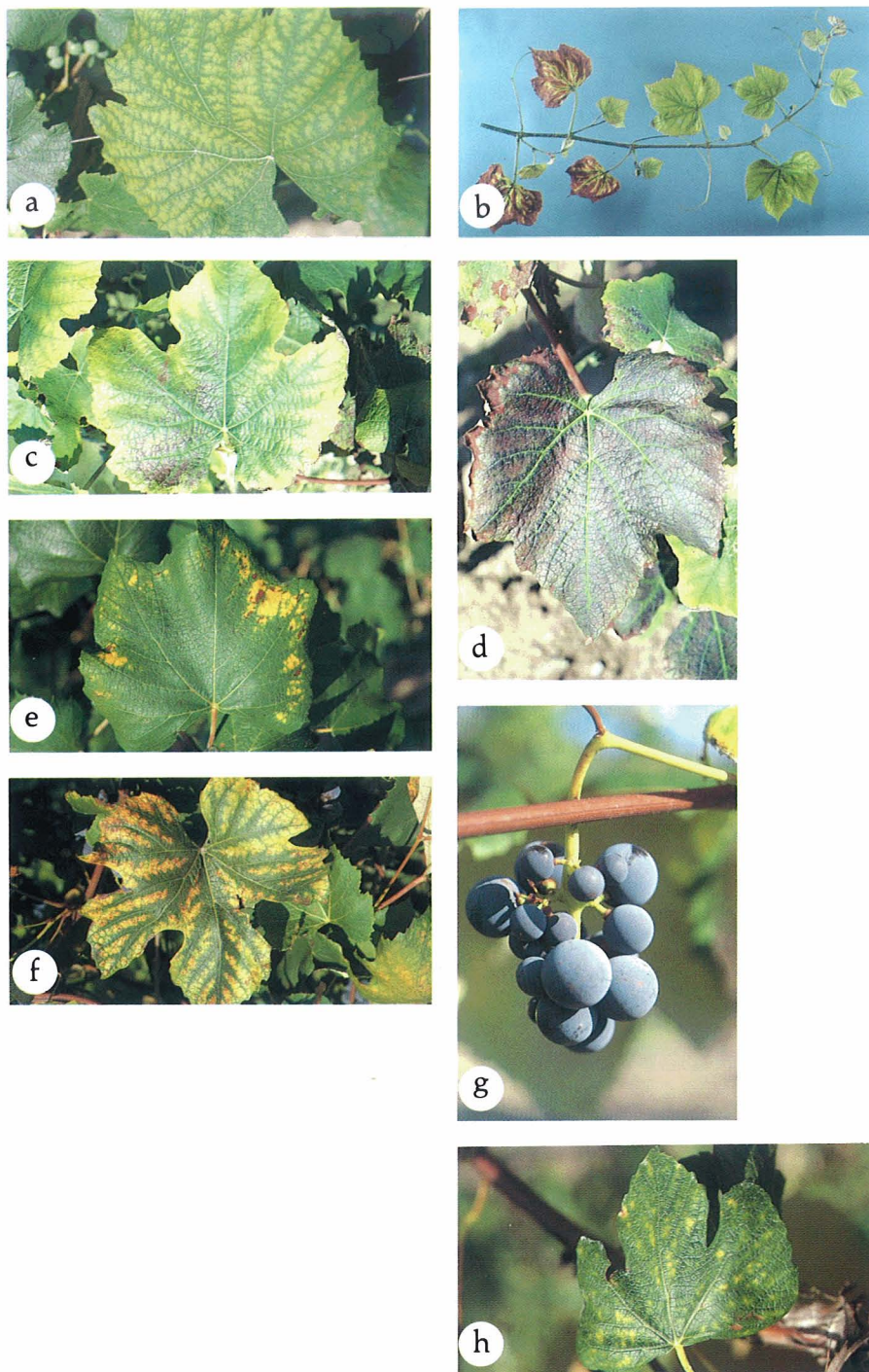


Plate I - Symptoms of nutritional deficiencies in grape vines to include: (a) leaf symptoms of manganese deficiency as indicated chlorotic "Islands" in the intervenial areas of the leaf blade, (b) leaf and shoot symptoms of iron deficiency as indicated by a chlorotic leaf pattern at the tip of the shoot, (c) mild leaf symptoms of potassium deficiency as indicated by marginal leaf scorch, (d) black leaf symptoms of potassium deficiency, (e) mild leaf symptoms of magnesium deficiency as indicated by a healthy, green margin of the leaf while the interior, intervenial area of the leaf blade shows chlorosis, (f) severe leaf symptoms of magnesium deficiency as indicated by extensive chlorosis of the leaf with intermittent rusty-brown necrotic lesions, (g) a boron- deficient cluster as indicated by the small number of berries per cluster and their irregular size, (h) a boron- deficient leaf as indicated by its cupped misshaped, and chlorotically mottled appearance.

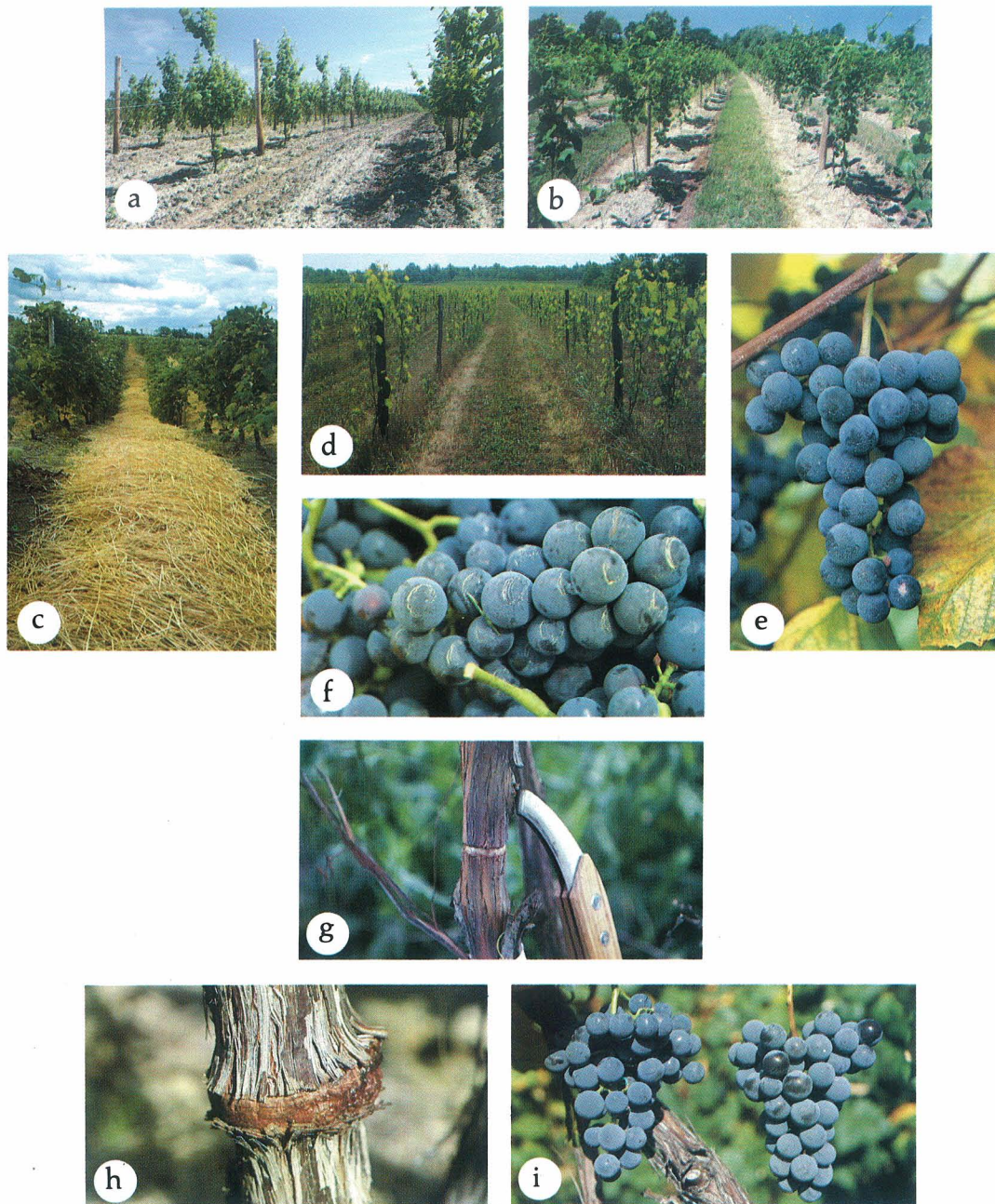


Plate II - A variety of topics related to Concord table grape production: (a) cultivation of row middles, (b) a permanent sod row middle, (c) a mulched row middle, (d) a row middle several weeks after it was sprayed with a herbicide, (e) a Concord cluster with objectionable levels of visible pesticide residue resulting from a spray pattern involving large spray droplets, (f) objectionable visible spray residue on the bottom of Concord berries resulting from a high-volume spray application, (g) a trunk girdle approximately 1/8 inch in thickness on a Concord grapevine and the tool used to make that girdle, (h) the callus formed on a Concord trunk several weeks after a girdle was made, (i) a comparison of a normal grape cluster (left) versus that which has been influenced by girdling (right). The cluster experiencing girdling shows larger berries.

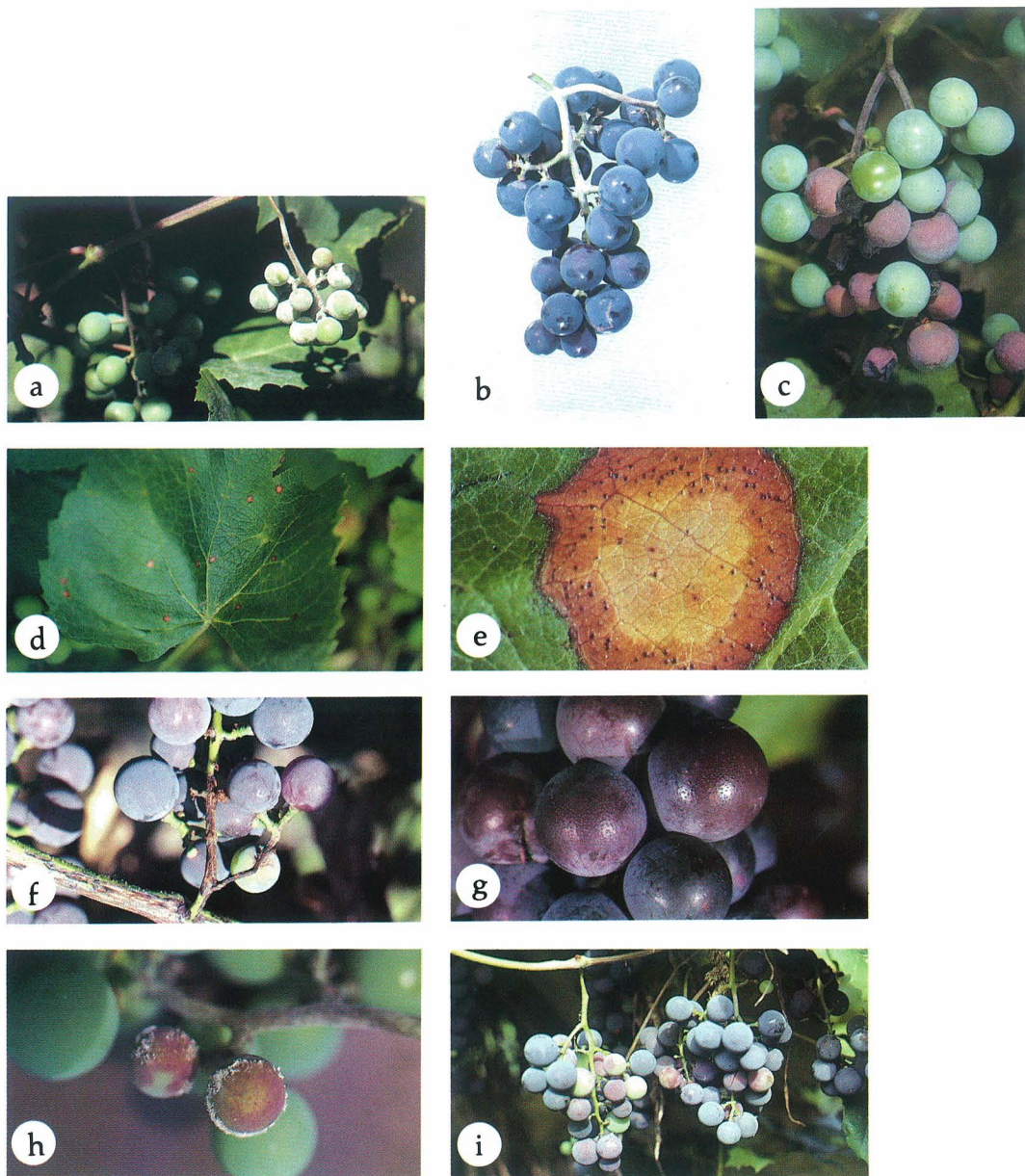


Plate III - Disease symptoms on Concord grapevines: (a) powdery mildew infection on berries and rachis shortly after fruit set, (b) powdery mildew infection on the rachis at the time of fruit ripening, (c) an early stage of black rot fruit infection, (d) a leaf showing the presence of black rot leaf infections, (e) a closeup view of a black rot leaf infection. The small black pimples are the summer fruiting bodies of this disease. They can release spores for subsequent infection of fruit and other tissues of the grapevine, (f) necrotic lesions on the shoot and rachis produced by infections of Phomopsis cane & leaf spot, (g) small pimple-like infections on the surface of Concord berries indicating infection by Phomopsis cane & leaf spot, (h) downy mildew on berries shortly after fruit set showing the characteristic white sporulation and (i) downy mildew infection of berries at the time of early fruit ripening.

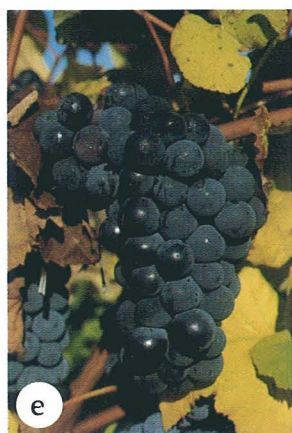
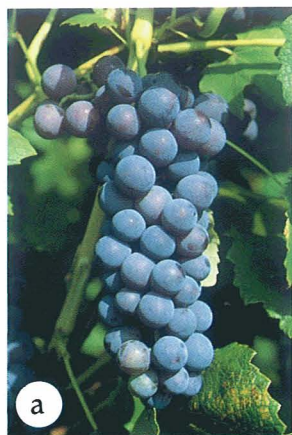


Plate IV - Promising Concord-type varieties to include (a) Alwood, (b) Bath, (c) Mars, (d) Price, (e) Sheridan and (f) Steuben.

of ten days apart. In cases of severe boron deficiency soil applications of one (coarse-textured soil) or two (fine-textured soil) pounds of actual boron per acre may also be helpful.

Because boron deficiency is often associated with eroded soils, a grower should work to halt and reverse the soil erosion process by reducing his cultivation practices in preference for other row middle management options, especially mulching.

Soil Acidity

New York Concord vineyards can have soil pH values as low as 3.0. Because many crops grow best when soils are in a pH range from 6 to 7, the question frequently arises whether or not it is desirable to lime New York Concord vineyards. Research on this topic (Gladwin, 1936; Upshall et al., 1947; Smith et al., 1972) indicates that liming a Concord vineyard either produces no benefit or is detrimental to the productivity of the vineyard. A grower should be very cautious about liming a Concord vineyard because applications of as little as one ton of lime per acre applied to a soil with a pH of 5.2 have induced potassium black leaf deficiency symptoms on Concord vines (Shaulis & Kimball, 1956). There are highly productive Concord vineyards on soils with a pH as low as 4.0. Therefore, there is little justification for the liming of a Concord vineyard for the purpose of raising soil pH. However, at times the application of dolomitic lime to a Concord vineyard may be justified for the purpose of correcting a magnesium deficiency.

Lastly, it should be noted that the risks of liming Concord vineyards do not extend to all grape varieties. There is evidence that French-hybrid and vinifera varieties benefit from liming in certain situations.

VINEYARD FLOOR MANAGEMENT

Good vineyard floor management is essential for a productive Concord table grape vineyard because in large part it determines the influence of two major stress factors on vine performance, i.e., water and nutrients. Good vineyard floor management promotes the development of large vines with well developed canopies which are the key to large, profitable yields.

The overall goal of vineyard floor management is to provide maximum nutrient and water availability to grapevines during the first part of the growing season while minimizing the risk of soil erosion. Soil erosion can indeed result in severe decline of a vineyard. For example, Alderfer & Fleming (1948) found a strong relationship between the amount of organic matter in vineyard soil and vineyard productivity. Their study of a Pennsylvania Concord vineyard showed a 32% to 48% reduction in yield when soil organic matter was reduced to one half or one third of the original level, respectively. The same study measured a 40% decline in yield when 4.5 inches of topsoil were lost due to erosion. Because control of soil erosion is such an important factor in the long term performance of a vineyard, good vineyard floor management is not simply a matter of minimizing short term water and nutrient stresses on the vineyard.

The vineyard floor is typically managed in two distinct zones, under-the-trellis and in-the-row-middles. Each of these zones is discussed separately as follows:

Under-the-Trellis Management

The growth of weeds under the trellis can have a very large impact on vineyard productivity. For example, R. Pool and co-workers measured the impact of under-trellis weed growth on grapevines. They found that this weed growth reduced vine size by as much as 40% and yield by as much as 45%.

Prior to the mid-1950's, mechanical weed control was the predominant method available to growers for controlling weeds under the trellis. Beginning with the horse hoe and later progressing to take-out plows on tractors, thousands of acres of Concord vineyard were managed in this manner. The advent of chemical weed control in New York vineyards came about 1953 (Shaulis & Jordan, 1974). Experiments by Shaulis and co-workers indicated that chemical weed control resulted in better vine performance than with mechanical approaches. The superiority of chemical weed control over mechanical approaches is likely due to a combination of better, longer lasting weed control and a reduction in mechanical injury to vine root systems. Chemical weed control also helps to reduce vineyard labor requirements. Today, weed control under the trellis in Concord vineyards is achieved predominantly by chemical means. However, there continue to be specific reasons for mounding the soil under the trellis. These include: (a) to avoid the risk concentrating herbicide sprays at the base of the vines and (b) to interrupt the flow of surface water across sloping ground, thus reducing soil erosion. In years following severe black rot occurrence, mounding of soil under the trellis can help reduce carry over inoculum by burying mummified black rot infected berries.

Successful chemical weed control under-the-trellis depends on understanding the nature of various weed species and the properties of various herbicides available for control of these weeds. Weeds can be placed into two categories according to their overwintering condition as follows: (1) those weeds that overwinter as seeds and (2) those weeds that overwinter as established plants on the soil surface or some type of underground structure such as rhizomes, tubers, bulbs, etc.

- **Control of Weed Seed Germination** - The first step in under-trellis weed control using herbicides is to interfere with the germination of weed seeds regardless of whether the weed is an annual, like ragweed or pigweed, a biennial like teasel and wild carrot, or a perennial like milkweed or quackgrass. If weed seed germination is not prevented, the control of an existing weed problem will be followed by new populations of weeds. Several available chemicals called preemergent herbicides interfere with weed seed germination. When applied to the vineyard floor, these highly water insoluble materials barely penetrate the surface of the soil, where they may remain active for relatively long periods of time.

At times growers become disappointed in the performance of preemergent herbicides because these materials have little or no affect on the weeds growing at the time of application. For best results, preemergent herbicides should be applied early in the spring before weed growth has begun or combined with contact or systemic herbicides.

Several preemergent herbicides are available for use in New York vineyards including Karmex (diuron), Princep (simazine), Surflan (oryzalin), Casoron (dichlobenil), Devrinol

(napropamide) and Solicam (norflurazon). The material of choice and the appropriate rate of application will depend upon factors such as the age of the vineyard, the weeds to be controlled, the type of soil and economics. Consult Cornell Cooperative Extension for your particular situation.

- **Killing Weeds Already Present** - The application of preemergent herbicides will do little to control most established weeds. Two other categories of herbicides, contact herbicides and systemic herbicides, are available for established weeds. As the name implies, contact herbicides kill only the plant tissues contacted by the material. Contact herbicides can be especially effective when the weeds present are annuals or biennials. However, the success in controlling perennials with contact herbicides will vary greatly. The extensive root systems of many perennial weed species will often survive the death of the above ground plant parts and support new growth soon after a contact herbicide application. Nevertheless, when other herbicides are ineffective or illegal, the contact herbicide approach to perennial weed control may be preferable to making no attempt at all to control weeds.

Perennial weed control is best achieved with properly timed applications of systemic herbicides, which kill the entire plant, thus preventing regrowth. There are many factors to consider when applying a systemic herbicide including: (a) the weed species to be controlled, (b) the choice of a herbicide, (c) the volume of water to be used per acre, (d) precautions for vine safety and (e) the timing of sprays. Consult the herbicide label and Cornell Cooperative Extension for details of the application of systemic herbicides.

The band width for under-trellis weed control should be carefully chosen so that it overlaps with the row-middle management program. For example, a 48" spray band under the trellis can be desirable when mowing row middles with a 5 foot rotary mower in a vineyard with a nine foot row spacing.

In summary, the control of weeds under-the-trellis is best accomplished by chemical means. This is a two step process involving the control of weed seed germination and the eradication of weeds currently present. Practicing either one of these steps without the other will often result in unsatisfactory vineyard floor management with the likelihood of significant reductions in yield.

Row-Middle Management

The four basic row middle management options are cultivation, permanent sod, herbicide spraying and mulching. Any one of these row middle management options may be an appropriate or even the best choice for one vineyard and the worst choice for another (Table 5). Assuming satisfactory weed control has been established under-the-trellis, row middle management will often be the principal method of managing vine size in a Concord table grape vineyard. At various times a grower may wish to increase, decrease, or keep vine size at the present level. The proper choice of row middle management will depend in part upon which of these conditions is desired. In general terms, mulching of row middles affords the best opportunity for vine size stimulation while a permanent sodded row middle affords the least. Cultivation and herbicide management systems are intermediate in their ability to stimulate vine performance.

Table 5 - Advantages and disadvantages of four vineyard row middle management options.

OPTIONS	ADVANTAGES	DISADVANTAGES
Cultivation	Less competitive than permanent sod	Erosion; possible root pruning; may need to sow cover crop; slower than mowing.
Permanent Sod	Erosion control; No annual cover crop; mowing faster than cultivation.	May excessively compete with vine growth.
Herbicide spraying	Total elimination of weed competition during critical period of vine growth; erosion control; reduces perennial weed problems in vineyard.	At times weed regrowth occurs too quickly
Mulching	Maximum vine size stimulation	Not for wet areas; or when vine size is optimum; more costly; requires special equipment and source of mulch

When making a choice of row middle management, a grower needs to consider: (a) the degree of vine size stimulation desired, (b) his ability and the equipment availability for applying a particular row middle management strategy and (c) the hazard of soil erosion for a particular vineyard. Each of the row middle management options is discussed as follows:

- **Cultivation of Row Middles** - This is still the most prevalent form of row middle management in New York vineyards (Plate 2a), but its use is declining. When properly practiced, cultivation of row middles is relatively shallow, about 2 inches, so that the growth of weeds or a cover crop is almost but not entirely eliminated. If the cultivation is so deep and/or so frequent that it totally eliminates plant growth in the row middles, detrimental root pruning of vines is likely to occur. Cultivation is a good method of row middle management, but it may create a high risk of soil erosion on sloping ground during the time it is practiced. Therefore, other row middle management options are preferable in these situations. Cultivation typically begins during May and ends in late July or early August. The duration of cultivation will depend upon the degree of vine size stimulation desired and the soil moisture in the vineyard. When cultivation is terminated, either a natural weed cover or a sown cover crop is allowed to grow in the row middles to slow vine growth, reduce soil erosion and minimize soil compaction by equipment during harvest. Commonly-used cover crops include rye, wheat or oats, which are sown at a rate of 1 1/2 to 2 bushels of seed per acre. The use of sown cover crops may be an unnecessary expense if weed regrowth is adequate to control erosion.

- **Permanent Sod Row Middles** - When vine size is considered adequate or excessive, this row middle management option may be desirable. Either a natural weed sod or one sown with

perennial grasses may be used. Red fescue or ryegrass sown at a rate of 10 lbs. of seed per acre have given satisfactory results. The use of legumes, alone or in combination with grasses, have not been shown to be an advantage in supplying nitrogen to vines. Birdsfoot Trefoil should never be sown in a vineyard because it can become a difficult-to-control weed under the trellis. When establishing permanent sodded row middles, establish them narrow enough to mow with a single pass of a rotary mower (Plate 2b). If competition needs to be minimized when using this approach to row middle management, mow frequently through July to keep growth of the sod to a minimum.

- **Mulching Row Middles** - In recent years there has been a significant increase in the practice of mulching row middles in New York vineyards (Plate 2c). This has occurred because increasing numbers of farmers have first observed and then experienced the benefits of mulching. The increased use of mulching in New York has been made possible because of the development of the technology for efficiently handling large quantities of mulch. Although mulching is not desirable on heavy, water-logged soils, in most vineyards this row middle management option provides maximum vine size stimulation. There are many benefits to be derived from mulching including increased nutrient availability, reduced risk of erosion and the conservation of soil moisture for use by grapevines. Mulching is especially useful on eroded vineyard sites. Water availability to grapevines appears to be the predominant mechanism in many situations causing a vine response to mulching. Therefore, for maximum benefit a mulching program should cover the soil surface. If weeds grow through the mulch, they should be controlled with herbicide applications. Mulch should always be applied to the soil surface. It should never be incorporated into the soil because this destroys the erosion control and soil moisture conserving properties of the mulch. Furthermore, incorporation of mulch can induce a temporary nitrogen deficiency. Research on the mulching of Concord vineyards by Beattie (1955) has shown that mulching can actually produce excessive vine size, which in turn can reduce both yield and fruit quality. Therefore, if vine size becomes adequate as a result of a mulching program, then the intensity of mulching should be reduced or eliminated altogether. More information on mulching materials and their use in vineyards is available from Cornell Cooperative Extension.

- **Herbicide Spraying of Row Middles** - In the 1950's when preemergent herbicides became available for use in New York vineyards, they were applied in some vineyards to the entire vineyard floor. Although this approach seemed desirable at first, it led to uncontrollable soil erosion which resulted from a lack of weed growth or cover crops in row middles. Consequently, preemergent herbicides are not recommended for use in row middle management.

In recent years systemic herbicides, and to a lesser extent contact herbicides, have been used to manage growth in row middles with encouraging results. With these approaches, a vegetative cover in the row middle is temporarily killed back. However, whether that cover is dead or alive, it controls soil erosion until regrowth occurs (Plate 2d).

Roundup (glyphosate) application to row middles has been shown to be as effective as cultivation in stimulating vine size. It not only provides the additional benefits of reduced risk of soil erosion, but also there is improved access of equipment in the vineyard. Some growers actually report increases in vine size and yield when row middles which were

formerly cultivated are sprayed with Roundup. Low volume spraying at 10 gallons of water per acre sprayed has allowed relatively low herbicide rates to be effective in controlling weeds in vineyard row middles. Additional details on rates, timing, as well as the construction of spray booms and other equipment for row middle application of Roundup are available from Cornell Cooperative Extension.

- **Alternate Row Combinations** - Many growers use various combinations of the four basic row middle management options by applying two options in alternating rows of a vineyard. The desirability of such combinations should be judged by the same criteria as for the individual row middle management options themselves. That is, does this combination stimulate adequate vine size while controlling soil erosion? If not, use another approach to row middle management. Consider the following examples: (a) If a grower were practicing an alternate row combination of permanent sod and mulching, and vine size were too small, then the permanent sod ought to be replaced with one of the other row middle management options. (b) If a permanent sod and cultivation combination were being used and there was too much soil erosion, the cultivation ought to be replaced by another row middle management option. Regardless of the row middle management combination used, the ultimate measures of the adequacy of a row middle management program are: (a) the control of soil erosion and (b) the development of optimum vine size.

In summary, good vineyard floor management is fundamental to a productive Concord table grape vineyard. The vineyard floor under the trellis and in the row middle are two distinct vineyard floor management zones. Under-trellis management is best achieved through a two step process of chemical weed control, which involves control of weed seed germination and the elimination of existing weeds. Four options including cultivation, permanent sod, herbicide sprays and mulching are available for managing vineyard row middles. The desirability of each of these will depend upon the characteristics of the particular vineyard being managed.

PEST CONTROL

Introduction

The disease and insect problems of Concord grapes grown for fresh market are no different than those of Concord grapes grown for any other purpose. However, there are two major reasons why the pest control strategies for the production of Concord table fruit may be quite different than those for producing Concord grapes for processing markets. First the high quality standards for fresh fruit dictate low tolerance for insects and diseases. Fruit injury levels, which may be quite acceptable for processing markets, are often unacceptable for fresh markets and the labor costs to remove injured fruit from clusters can be prohibitive. Secondly, the occurrence of visible residues on fruit from pesticide sprays is an additional undesirable factor facing the Concord grape grower whose crop is destined for fresh market.

A Concord table grape grower must carefully plan his spray program because it must be more effective and yet result in less visible residues than programs generally used to produce Concord grapes for other markets. The following information discusses the principal pest

problems associated with Concord table grapes, some considerations for minimizing visible pesticide residues and strategies for developing an effective spray program.

The Principal Disease and Insect Problems Affecting Concord Table Grapes

There is a relatively long list of diseases and insects that can affect Concord grapevines. We present here only those which are most threatening to the production of quality Concord fruit for table use.

• Powdery Mildew

Effects on Fruit Quality and Storage Life - In general, infection of Concord fruit by the powdery mildew fungus is fairly rare. However, when it does occur the shoulder of the berry typically has an unsightly whitish-gray, dusty growth (Plate 3a). As the fruit ripens, the affected area does not develop an intense color, giving the berry a blotchy ripening appearance. The grayish dusty appearance of the fungus remains on the fruit through harvest.

The most serious injury to Concord from powdery mildew is infection of the rachis. This can occur throughout the growing season. Infected cluster stems have a whitish-gray, dusty covering of fungus growth (Plate 3b). Such infections may result in brittle clusters, making them more difficult to pick and pack. Cluster stem infection becomes especially damaging when grapes are put into cold storage. Under these conditions, infected cluster stems wilt, turn brown and the storage life of the fruit is significantly shortened.

Considerations For Control - The powdery mildew fungus overwinters as small, black, spherical bodies in bark crevices on the vine. During spring rains these fruiting bodies open and discharge their spores. Primary infection of the new growth occurs soon after bud break, but the disease does not become obvious to the trained eye until late May or early June under New York conditions. Most growers first notice powdery mildew after bloom.

The period of most active growth for the powdery mildew fungus in New York usually occurs during the month of July. Spread of the disease in summer is generally not limited by New York climatic conditions, except during periods of abundant rainfall. Berries are susceptible to infection from fruit set until they contain approximately 8% sugar with the cluster stem remaining susceptible beyond this period. The disease continues to develop on foliage after harvest and the fungus produces its overwintering structures as long as green tissue is present. Rainfall in summer and early fall redistributes these structures to the bark where they overwinter and provide spores the following spring to renew the disease. A discussion of the complete cycle of this disease and color plates showing its appearance are presented in the Grape IPM Disease Identification Sheet No. 2.

Unlike traditional spray programs for Concord grapes destined for processing markets, a powdery mildew control program for Concord table grapes should begin well before bloom. By keeping cluster stems and berries free of infection early in the season, the development of powdery mildew will be slowed later in the season (August-September), when spray schedules must be reduced to avoid visible spray residues.

• Black Rot

Effects of Disease on Fruit Quality and Storage Life - Black rot is a disease of green fruit (Plate 3c). Infected berries eventually become black, shriveled mummies. In addition to loss of berry weight, the entire cluster will be unsaleable for fresh fruit if more than a few berries become infected. Mummified fruit is unappealing and its costly removal gives the cluster an unbalanced, scraggly appearance. If the cluster stem becomes infected and eventually girdled by black rot, that portion of the cluster beyond the infection may shrivel and be lost. There is little direct effect of the disease in storage.

Considerations For Control - The black rot fungus overwinters in mummified fruit. During spring rains, spores of the fungus are released from fruiting bodies in these mummies. Rainfall is essential for black rot infection to occur. Infection depends upon a combination of favorable temperatures and the number of hours susceptible vine tissues are wet from rain or dew. (Table 6). Black rot lesions on leaves have the appearance of rusty brown circular spots, typically 1/8-1/4 inch in diameter (Plate 3d). The key identifying characteristic of a black rot leaf infection is the appearance of small black pimples just within the edge of the spots (Plate 3e). A complete description of the disease cycle of black rot can be found in the Grape IPM Disease Identification Sheet No. 4.

Table 6. Hours of continuous leaf wetness from rain or dew required for a Black Rot infection period at different temperatures. Data from R.A. Spotts, Ohio State University.

Temperature (°F)	Hours of Leaf Wetness
50	24
55	12
60	9
65	8
70	7
75	7
80	6
85	9

The key to successful black rot control is early season prevention of disease development. Early season infections occur on the basal leaves of shoots which are in close proximity to developing clusters. Such black rot lesions provide a concentrated source of spores to spread the disease to the clusters and younger leaves. With each rain event, a new crop of spores may be transmitted to the developing fruit. Once black rot has gained a foothold, control of this disease involves a difficult fight throughout the season until the fruit begins to ripen. Therefore, the best control strategy for black rot begins with early season sprays to prevent primary infections on the leaves and clusters.

Some fungicides have post-infection activity which can eradicate black rot infections with 72 hours of their initiation. However, to practice such an eradication strategy a grower must monitor temperatures and wetting periods (Table 6) to determine if an infection period has taken place. Once one has occurred, a special spray must be applied just after infection but long before symptoms appear.

Cultivation under the trellis prior to bud break to bury the mummies is an effective way of reducing overwintering inoculum.

• **Phomopsis Cane and Leaf Spot**

Effects of Disease on Fruit Quality and Storage Life - Phomopsis may directly destroy the fruit through infection or indirectly by infection of the cluster stem with subsequent withering of the cluster beyond the point of infection (Plate 3f). The cluster stem can also break at the point of infection causing considerable loss of fruit. In contrast to black rot, Phomopsis fruit rot tends to develop on ripe fruit. Infected fruit first develop a brownish color and later are covered with small pimple-like bodies (Plate 3g). They rarely become hard and black or persist on the cluster like black rot mummies. Infected fruit frequently drop from the cluster leaving a dry stem scar. The fungus may continue to develop in infected fruit during storage, which reduces the quality of the product.

Considerations For Control - Phomopsis overwinters in infected bark and in debris such as dead shoots and cluster stems. Spore release and infection are dependent upon rainfall. The first infections may occur in young tissue soon after bud break. Shoot and cluster stem infections are most common from bud break until shoots are 6-8 inches long. Lesions appear 3-4 weeks after infection.

Berry infection appears to develop in two ways, either through infection of the pedicel (Figure 28) from which the fungus moves into the fruit or directly through the skin of the berry. Current research in New York indicates most fruit infection may actually occur during or shortly after bloom. Further information on symptoms and disease cycle are presented in Grape IPM Disease Identification Sheet No. 6.

Phomopsis cane and leaf spot can be controlled by pruning out dead and infected canes and by the use of early season protectant fungicides. Sprays are recommended at 1-3 inches of shoot growth and again at 5-6 inches of growth. Sprays at bloom help reduce the fruit rot phase of the disease. Training systems that maintain old wood above the fruit tend to promote the disease and two or more early season sprays may be needed in these vineyards. Infected canes and dead wood should be removed during pruning.

• **Downy Mildew**

Effects on Fruit Quality and Storage Life - Although downy mildew is not generally a major problem on the Concord variety, fruit infection can make clusters unsaleable for table use. Early season fruit infection (bloom to mid-July) gives rise to stunted yellow-green berries that may have white sporulation of the fungus on their surfaces (Plate 3h). These berries usually shrivel and drop from the cluster or they are hidden by the enlargement of healthy berries.

Infection of more mature berries is not obvious until healthy berries have begun to color. Infected berries fail to color properly, become pinkish (Plate 3i) and remain firm as compared to healthy berries that soften as they ripen. Infected berries may drop from the cluster leaving a dry stem scar.

If the cluster stem is infected, it eventually turns brown and dries. Portions of the cluster beyond the infection wither and may drop. In storage, infected cluster stems continue to desiccate and infected berries become invaded by other rot organisms.

Considerations For Control - The downy mildew fungus overwinters in infected grape leaves on the vineyard floor. In spring, spores are rain splashed to susceptible green tissues, where new infections occur. Subsequent spread of the disease is determined by availability of adequate moisture (rainfall or heavy dew). Fruit infection may occur from fruit set through July under New York conditions. Additional information on symptoms and disease cycle are presented in Grape IPM Disease Identification Sheet No. 5.

Early season sprays are important for the control of this disease.

• Grape Berry Moth

Effects on Fruit Quality and Storage Life - Concord vineyards vary considerably in their history of grape berry moth infestation and some growers have no problems with this pest. The significance of this pest for Concord table grape growers relies on the fact that even modest levels of berry moth damage can make the crop unmarketable for fresh fruit.

Considerations For Control - There are four distinctly different stages in the grape berry moth life cycle. The tiny egg, the worm-like larval stage, the mummy-like pupal stage and the small adult moth. Only one of these stages, the pupal stage, survives the winter. Pupae overwinter in leaf litter on the vineyard floor. During mid-May the small moths emerge from these overwintering pupae and deposit eggs on grape clusters, primarily at the vineyard's edge. The eggs are difficult to see. The newly hatched larvae bore into the berry on which the egg was laid. Adults and eggs are susceptible to insecticides recommended for berry moth control. In addition, 30-90% of berry moth larvae residing in grape berries can be killed following insecticide treatments. The second adult generation of berry moth emerges in mid to late July. The third adult generation can emerge as early as mid to late August, which may pose a serious threat to table grapes, especially during years of high infestations. The Grape IPM Insect Identification Sheet No. 1 presents details on grape berry moth biology and helpful photographs of the life stages. New York Food and Life Sciences Bulletin 120 "Assessing the Risk of Grape Berry Moth Attack in New York Vineyards" describes procedures for monitoring grape berry moth damage in vineyards.

Minimizing Visible Residues on Concord Grapes

Any evidence of visible spray residues on food is highly objectionable to today's consumer. The fact that these residues may be inert carriers of the pesticides makes no difference as far as most consumers are concerned. Therefore, to enhance the marketability of the crop, the Concord table grape grower must make every effort to minimize the occurrence of visible residues. This task is made especially challenging given the dark blue surface of Concord berries. Approaches to a vineyard spray program which can help to minimize visible residues on fruit surfaces are as follows:

- Water Gallonage - The use of large volumes of water to apply pesticides to a vineyard can provide good distribution of materials and effective control of diseases and insects but it results in large drops of residue on berry surfaces (Plate 2e), especially as sprays flow to the

bottom of berries (Plate 2f). Such residues often persist for long periods even when rainfall is abundant. Therefore, table grape growers should concentrate their sprays in the range of 25-50 gallons of water per acre.

- **Spray Pattern** - Low water gallonage per acre in itself will not minimize visible pesticide residues. The spray pattern in terms of droplet size is also important. Large spray droplets produce larger, more persistent residues on berry surfaces (Plate 2e) than small droplets. Nozzle orifices, which are too large or worn nozzle tips, can create a "garden hose" spray pattern. This should be avoided. To reduce visible residues select a combination of nozzle size and sprayer pressure which provides a spray pattern with relatively small droplet sizes. Check nozzle orifices periodically for wear and replace them as necessary.

- **Choice of Materials** - Many of the pesticides commonly used in the New York grape industry are formulated as wettable powders, which are applied at relatively high rates (pounds per acre). Whenever possible these materials should be avoided after the first postbloom spray in a table grape spray program. Fortunately, there are fungicides currently available to growers that are used at relatively low rates (ounces per acre). Their use in postbloom sprays is quite helpful in limiting visible residues. For example, in a mid summer trial to evaluate visible residues, the use of Bayleton 50W at 2 oz. per acre resulted in less visible residues than other fungicides used at 2.5 to 3.0 lbs. per acre (Table 7).

There are a number of insecticides available to growers in liquid formulations and their use generally results in considerably less visible residue than the use of insecticides in wettable powder formulations. For example, the data in Table 7 indicate a dramatic difference in visible residue when comparing a wettable powder formulation of Sevin versus a liquid formulation of PennCap-M. Copper & lime sprays are also undesirable in table grape spray programs due to the long persistence of lime residues.

TABLE 7. Results of a 1987 field trial which evaluated the visible residue on Concord berries treated with six pesticides at four times during the growing season. Materials applied with 20 gallons of water per acre and without adjuvants. Clusters from each treatment were rated as follows: 0 = no visible residue; 1 = slight but non-objectionable residue for fresh fruit marketing; 2 = moderate and somewhat objectionable residue for fresh fruit marketing; or 3 = heavy and highly objectionable residue for fresh fruit marketing. Total scores from 100 clusters for each treatment were placed into categories as follows: None = 0; Slight = 1-25; Moderate = 26-50; Heavy = 51 +. Ratings were made on 9/10/87.

MATERIAL [rate/acre]	DATE OF APPLICATION (Days after full bloom)			
	July 1 (18)	July 13 (20)	July 27 (44)	August 13 (61)
BAYLETON (50WP) [2 oz.]	NONE	NONE	NONE	SLIGHT
PENNCAP-M (2FM) [2 pt.]	NONE	NONE	NONE	SLIGHT
CAPTAN (80WP) [2.5 lb.]	NONE	SLIGHT	HEAVY	HEAVY
DITHANE M22 SPECIAL (80WP) [3 lb.]	NONE	SLIGHT	HEAVY	MODERATE
DITHANE M45 (80WP) [3 lb.]	NONE	SLIGHT	HEAVY	MODERATE
SEVIN (80S) [2.5 lb.]	NONE	HEAVY	HEAVY	HEAVY

In summary, select carefully the pesticides which will be used in sprays after the first postbloom spray. Preference should be given to fungicides which are used at relatively low rates per acre and to insecticides which are available in liquid formulations. Information on the efficacy of specific pesticides is presented in the Cornell Cooperative Extension Grape Pest Control Guide.

- **Early Season Sprays** - As previously discussed, good control of many of the major disease problems of Concord table grapes can be achieved by initiating a spray program early in the growing season. This approach will often reduce the threat of disease injury to fruit later in the season, thus allowing a grower to reduce the intensity of his postbloom spray program. This is a useful strategy for minimizing visible residues because many spray materials can cause visible residues at harvest when applied as early as mid-July.

Strategies for a Concord Table Grape Pest Control Program

The development of a Concord table grape pest control program is a challenging task because it must be considered not only in terms of its efficacy against insects and diseases but also in terms of avoiding visible residues on fruit. In fact, these two goals may be in direct conflict with each other because the more a grower sprays to reduce the risk of disease and insect damage to the fruit, the more he risks incurring objectionable levels of visible residues. Given this conflict, a compromising strategy for pest control in Concord table grapes will often aim to greatly reduce the risks of insect and disease damage to fruit without expecting to completely eliminate such risks. Given other factors, such as economics, personal preferences for specific spray materials, changing disease and insect pressures, and weather, no single "recipe" will be appropriate as a spray program for all Concord table grape vineyards. Nevertheless, there are some basic strategies which can guide the development of spray program in Concord table grapes as follows:

- **Begin a Concord table grape spray program early.** Control primary infections of powdery mildew and black rot by beginning fungicide sprays when shoots are 3-6 inches long. Where control of Phomopsis cane and leaf spot is desired, apply the first spray when shoots are 1 - 3 inches long.
- **Maintain tight spray intervals early in the season.** Depending upon the material being used and the disease being controlled, the period of protection will typically range from 7 to 14 days.
- **Protectant fungicides must be present on the vines prior to rain to control black rot, downy mildew and Phomopsis cane and leaf spot.** When rainfall eliminates pesticide residues on vines, reapply materials just as soon as possible. During periods of frequent rainfall the use of locally systemic fungicides can help maintain protection against infection of some diseases.
- **Always apply a spray at the start of bloom to control black rot.** If the period of protection for powdery mildew has lapsed since the last spray, also apply a fungicide at the start of bloom for this disease.

- Apply the first postbloom spray no later than 7 days after the prebloom spray or when 90% of the florets have opened on the clusters, whichever comes first.
- In the first two postbloom sprays include an appropriate insecticide for grape berry moth control if the vineyard has a history of this pest.
- Choose carefully the pesticides used in sprays after the first postbloom spray. If possible, select fungicides which are applied at rates of ounces rather than pounds per acre. Use insecticides in liquid formulations.
- Carefully inspect the vineyard a week after the second postbloom spray. Adjust the intensity of the remaining spray program based on the current level of disease and insects in the vineyard and on the weather.
- An alternative strategy for controlling black rot in the postbloom period is to monitor vineyards for black rot infection periods and apply eradicant fungicides accordingly.
- Vineyards with a history of grape berry moth should receive an insecticide spray mid-season, i.e., about the end of the first week of August in many locations in New York. Contact Cornell Cooperative Extension for the precise timing of this spray.

These strategies can help design a spray program which is effective yet minimizes the risk of visible residues. Nevertheless, any spray program may require modification as disease and/or insect pressures build or weather interferes with planned sprays. Therefore, effective pest management for Concord table grapes requires more than the design of a good initial spray program. A grower must also: (a) know the insects and diseases affecting Concord grapevines, (b) know the pesticides available to control these pests and (c) monitor his vineyard frequently so that adjustments can be made to the spray program as current conditions warrant.

SPECIAL PRACTICES

Several special viticultural practices which are the subject of current research, can significantly alter the fruiting characteristics of Concord grapevines. Three of these practices are presented below for the purpose of making growers aware of the current status of these topics. No recommendation is given or implied regarding the commercial application of these viticultural practices. Consult with Cooperative Extension for recent developments in these areas.

Chemical Sprays to Increase Fruit Set

The product daminozide (Alar) has been shown to increase the set of berries on Concord clusters (Cahoon et al., 1977; McCaskill and Morris, 1977). Proper application of this product typically results in the set of 3 to 7 additional berries per cluster, which is generally advantageous to the Concord table grape grower in terms of cluster compactness and yield. However, a possible negative impact of Alar on fruit quality is up to a 6% decrease in berry weight. Moreover, vines which are over cropped because they are too small to sustain the additional crop load resulting from an Alar application and/or because they were not pruned severely enough, will respond to Alar applications with reduced fruit maturity and declining

vine size. Therefore, to produce quality Concord table grapes, Alar is suitable only on medium-to-large vines which have been pruned to a 30 + 10 pruning formula.

It should be noted that there is uncertainty regarding the future registration of Alar for use on Concord grapes. Some grape processors currently request that this product not be used on fruit to be delivered to them. Therefore, growers should check the current registration and when appropriate, consult with their processor before using this material.

Shoot Topping to Increase Berry Set

The mode of action of Alar for increasing berry set in Concord grapevines is hypothesized to be a temporary reduction in shoot growth, which in turn diverts the vine's "energies" into setting more fruit. Research originating with R. Pool and his co-workers indicates that if a sufficient portion of the terminal end of a Concord shoot is removed at the proper time, an increase in the weight of clusters on that shoot is likely to occur.

TABLE 8. The influence of shoot topping and trunk girdling, alone or in combination on berries per cluster, berry weight, cluster weight, yield and soluble solids. There were 605 vines per acre which were managed with a modified-Munson training system, shoot-positioned, and balance-pruned to a 30 + 10 pruning formula. Shoots were topped and trunks were girdled on 6/8/87 when vines were at 25% bloom. Crop harvested on 9/29/87.

Treatment	Clusters Per Vine	Berries Per Cluster		Berry Weight (g)	Cluster Weight (lbs.)		Yield Lbs./Vine	Soluble Solids (%)
		All ¹	BCO ²		All ¹	BCO ²		
Check	122	28	35	3.24	0.20	0.25	24.1	17.5
Shoot Topping	120	40	59	2.93	0.26	0.38	31.7	17.3
Trunk Girdling	126	32	44	3.63	0.26	0.35	33.2	16.4
Shoot Topping & Trunk Girdling	126	49	60	3.15	0.34	0.42	42.0	15.6

1. All clusters on vine.

2. Basal clusters only.

A typical response from shoot topping is an increase in the number of berries per cluster and a modest decrease in berry size. For example, in one study (Table 8) shoot topping resulted in a 43% increase in berry set for all clusters on the vine and a 10% decrease in berry size. The result was a 30% increase in overall cluster weight. Current research by R. Pool is investigating the mechanization of shoot topping to determine if it might be commercially useful.

Girdling

Winkler et al. (1974) credit the origin of the girdling of grapevines to a report by Lambry in 1817. Husmann (1898) acknowledges a Colonel Buchott in 1745 as the originator of this practice. Whatever its origin, girdling of grapevines is an old viticultural practice. In today's commercial world of viticulture, girdling is predominantly practiced on seedless table grape varieties to increase berry size, which is often unacceptably small in these varieties.

Girdling can also influence the development of berry size (Plate 3i) and the maturation of fruit in seeded grape varieties. Girdling was first performed on Concord grapevines in the 19th Century. Bailey (1893) wrote: "Heavy crops can be obtained from it (girdling) if liberal fertilizing and good cultivation are employed, and the fruit is always first class. A Concord vine trained in this manner produced in 1892 eighty clusters of first quality grapes, weighing forty pounds". Paddock (1898) researched girdling on Concord and several other varieties. He reported that girdling increased berry size of Concord and hastened maturity by seventeen days.

The girdling procedures used today are quite different from those used on Concord vines almost a century ago. At that time girdling removed from one half to one inch of tissue on canes. Girdles that wide prevented callus growth from reuniting the tissues above and below the girdle. Current techniques involve removing a ring of tissue only 1/8 to 3/16 inches in thickness (Plate 2g) and, under proper conditions, callus reunites the tissues above and below these girdles in about three weeks (Plate 2h). Another difference between girdling of Concord vines a century ago and now is that girdling was practiced much later in the season years ago than with our current methods. Such late girdling further reduced chances for callus to reunite tissues above and below the girdle. Therefore, the vine-weakening effect of the girdling procedures used in the 1800's was likely much greater than those we employ today.

Because the girdling techniques used on Concord vines in the 19th Century were so destructive, Concord growers at that time cleverly devised schemes to reduce the negative, vine size depressing impact of girdling. Their strategies included: (a) girdling beyond the fifth node of fruit canes, (b) girdling only half of the fruiting canes on a vine or (c) girdling every other year. All these approaches left some shoot growth unaffected by the girdle which could sustain the trunk and root portions of the vine.

Over the past decade we have used a similar strategy in managing cool climate seedless table grape varieties by placing cane girdles on the third internode from the base of a cane and leaving 2-node spurs in the head region of the vine. Vines of seedless table grape varieties managed in this manner have performed well without loss of vine size for several years.

Thus far we have two years experience with girdling the Concord variety. In 1986 girdling of Concord vines increased berry weight by as much as 27% (Plate 2i) and hastened fruit maturity by about two weeks. In 1987 (Table 8) trunk girdling of Concord vines resulted in a 14% increase in berry set on clusters and a 12% increase in berry weight. The combined effect was a 30% increase in cluster weight.

Because girdling is able to significantly improve fruit quality as well as advance the marketing period for Concord table grapes, this viticultural practice might be of great value to the New York Concord table grape growers. However, evaluation of the long term influence of modern girdling techniques on Concord grapevines will be necessary before the commercial worth of this practice can be fully determined.

HARVESTING

Time of Harvest

The maturity of a grape can be defined in terms of the balance between its acid and sugar concentrations. However, the most practical approach for identifying the proper time to begin harvest is to simply taste the fruit when berries have attained full color for the variety.

Studies of Concord grapes grown at Fredonia in 1984 and 1985, two seasons in which freezing temperatures and berry splitting were not vineyard problems until very late in the fall, indicated that mid-October was the best time to pick Concord grapes for storage for the Thanksgiving market. These two studies also suggested that heavy cropping, which significantly reduced sugar levels in the berries, did not delay the optimum harvest date for storage. However, in a year with poor weather during harvest, the situation can be quite different. Storage studies of Concord grapes grown in 1986, a wet growing season followed by a wet harvest period, showed best fruit quality was obtained at early harvest because berry shrinkage was less (Figure 23) and berry decay was less (Figure 24) than with fruit harvested later in the season.

If one waits until late in the harvest period, rain may frustrate attempts to harvest a quality crop. Concord grapes picked while wet develop decay in storage much more rapidly than grapes picked dry (Figure 24). Harvest of fruit should be delayed whenever clusters are not completely dry. Fall rains may also cause high incidences of berry splitting. Split berries decay rapidly in storage and will show unsightly sulfur dioxide (SO_2) injury if treated with SO_2 to retard decay. In summary, because hand labor is often limited and late harvest season weather is always unpredictable, it is advisable to pick grapes to be put into storage within two weeks of the date they reach early market maturity.

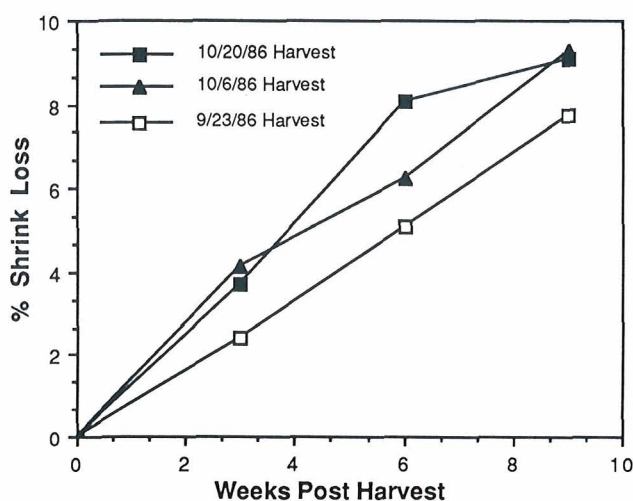


Figure 23 - Shrinkage weight loss of Concord grapes which were picked on three dates and evaluated after 3, 6 and 9 weeks of storage.

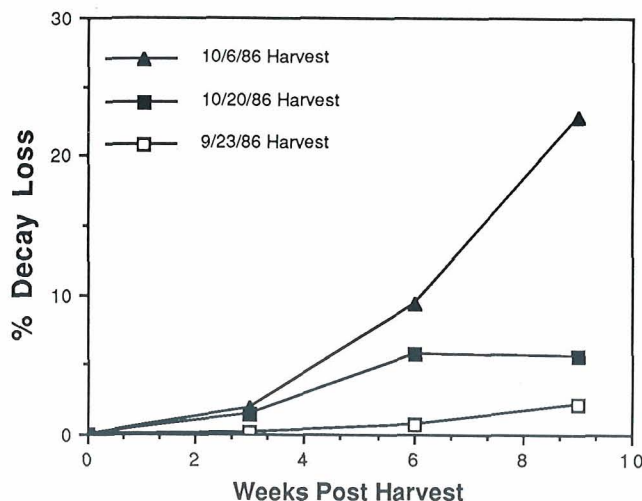


Figure 24 - The percentage of decayed Concord fruit, which was picked on three dates and evaluated after 3, 6 and 9 weeks in storage. Rain occurred the day before and day of the middle harvest date. Consequently, the grapes of that harvest were stored in a wet condition. They exhibited a faster rate of decay in storage than those of the other harvest dates.

Harvest Procedures

Containers - Harvest into field lugs followed by repacking of New York Concord table grapes is not recommended because each time the clusters are handled, more bloom is removed from the berries, more berries are loosened from their pedicels, more berry shatter occurs and more water loss and subsequent stem browning results from bending of the stems. The additional supervision of packing and handling of packing materials in the vineyard is more than justified by the better fruit quality obtained with in-row packing than with centralized packing. Therefore, in-row packing by the pickers is recommended.

Concord table grapes are typically packed into 1, 2, 4 or 8-quart baskets with the 1-quart, 2-quart and sometimes 4-quart containers transported in master containers. Master containers should be sized to fit a 40 x 48 inch supermarket pallet and to make a tight load in 88 or 96 inch wide truck beds. A container size of 24 inches by 16 inches will meet these requirements (Fig. 25). The inside height should permit adequate clearance space between the berries and the lid of the master. Remember that Concord grapes will not tolerate the tight packing sometimes used with other table grape varieties. Consequently, more container volume per pound is needed. Allow a minimum of 1.4 cubic feet of container volume for 20

pounds of Concord table grapes. Other important features of master containers include: (a) water resistant or wax coated cardboard on the outside to protect boxes from dew and wax impregnated corrugations to maintain container stacking strength in humidified storage, (b) numerous properly located ventilation holes to permit air to circulate through the container, (c) well-designed, attractive promotional material on the package and (d) labelling to adequately identify contents by variety, consumer unit and grape quality. Labelling to allow for coding of the farm, vineyard block and even the picker will also be useful. Typical master containers now in use hold either twelve 1-quart or six 2-quart consumer units and have a net weight of about twenty pounds of grapes. Consumer containers should also contain small ventilation openings to facilitate movement of air inside the master containers. Consumer containers must be labelled to indicate their volume, typically in units of dry quarts. Advertising and promotion information is often printed on consumer containers as well as the shipping master.

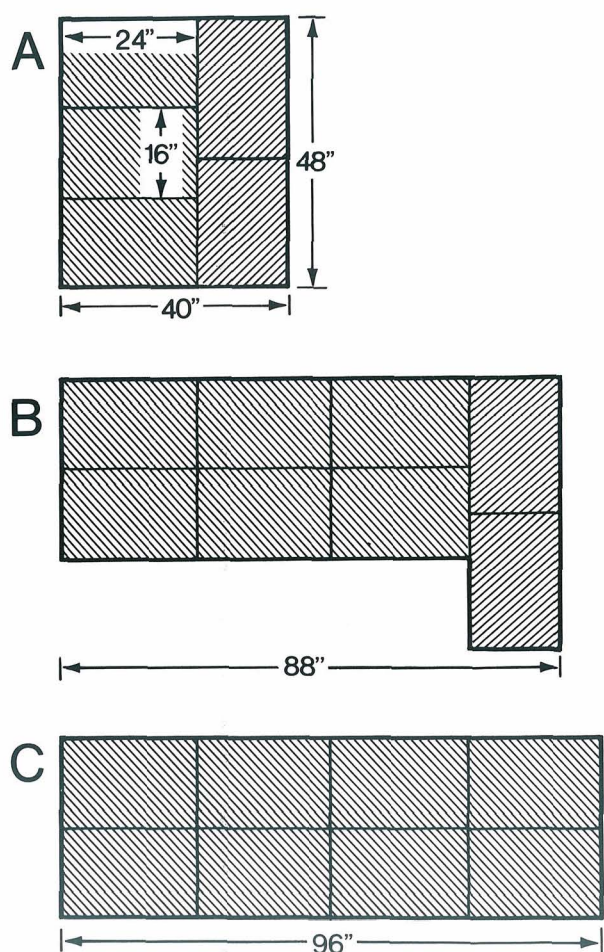


Figure 25 - A diagrammatic sketch of master containers (16 X 24 inches) stacked on: (a) a supermarket pallet (b) an 88 inch wide truck bed, and (c) a 96 inch wide truck bed.

To prepare containers for harvest, the empty consumer-unit containers are placed into master containers. Palletized master containers can then be transported to the vineyard when they are needed. A covered wagon, enclosed truck or at least tarp should be set at the edge of the vineyard to protect empty and filled containers from rain. Empty containers are distributed from a trailer ahead of the picking crew. Filled containers should be left in the shade under the vines by the pickers. Pick-up from two rows at a time is accomplished by hauling a trailer down alternate rows of the vineyard and then loading filled cartons on a truck or wagon waiting to transport the grapes from the vineyard. When rain is threatening, placement of empty containers and removal of full containers should be closely coordinated with progress of the harvesting crew.

Picking - The availability of harvest labor is often the most limiting factor for a Concord table grape enterprise on New York farms. A typical farm situation combines a relatively small number of experienced pickers with a frequent turnover of inexperienced pickers. The inability of many growers to assemble large picking crews is a matter of economics. Growers have repeatedly discovered in recent years that there is a large, accessible market for Concord table grapes. However, the economics of that market along with the competing economics of processing markets for Concord grapes ultimately limit the cost a grower can justify for harvesting Concord table grapes. If the harvesting cost per unit rises too high, then a grower is likely to find it more profitable to harvest his crop for a processing market.

From the perspective of the picker the financial reward is directly dependent upon the number of boxes per hour that can be harvested. Too often the harvest rate of an individual is too slow to provide for adequate compensation for the many challenges involved with this work. Labor regulations require that the rate of compensation for piecework activities comply with the minimum wage law. Therefore, it becomes critically important that a grower organize his table grape harvesting activity in a way that will maximize both worker productivity and the wage rate per hour. To attain this goal, the following factors should be considered.

- **Work Environment** - Create a well-structured plan starting with good leadership. One possibility is to hire a crew leader who can both oversee as well as demonstrate efficient harvesting techniques. Pickers should be shown how to select compact clusters with berry size and color which meet the grade being picked, are mature (juicy and palatable), exhibit no spray residue, yet are free of disease and insect damage and are firmly attached to the pedicels. They should be shown how to trim clusters close to the shoulder of the cluster and trim out straggly portions of clusters and individual cull berries, and how to carefully pack the clusters to maximize eye appeal and minimize damage. Details on grade requirements for eastern grapes can be obtained from local U.S.D.A. food inspectors or Cornell Cooperative Extension.

Create a spirit of friendly, team effort. Compliment work that is well done and diplomatically correct problems early in the training period of a new employee. Provide close supervision and encouragement to new employees in the beginning. Most people want to succeed and it's difficult to retrain an individual after he or she has become discouraged by a poor, inefficient first experience. Provide restroom facilities, drinking water, etc. close at

hand so individuals can work as efficiently and as comfortably as possible. Some growers offer a bonus for those who work the entire harvest season.

- **Materials** - Be sure the materials used in the harvest contribute to harvest efficiency. Be sure the picking shears are sharp and in a good working condition. The best picking shears have blunt, curved blades to minimize berry puncture and facilitate removal of shriveled, green and shot berries as well as straggly portions from the clusters. These expensive shears are frequently used by professional grape pickers who own their shears. Less expensive shears with straight blades and pointed tips are frequently used by growers who employ transient part-time pickers who usually don't want to purchase expensive shears. Provide supplies so people can clean and oil their shears periodically.

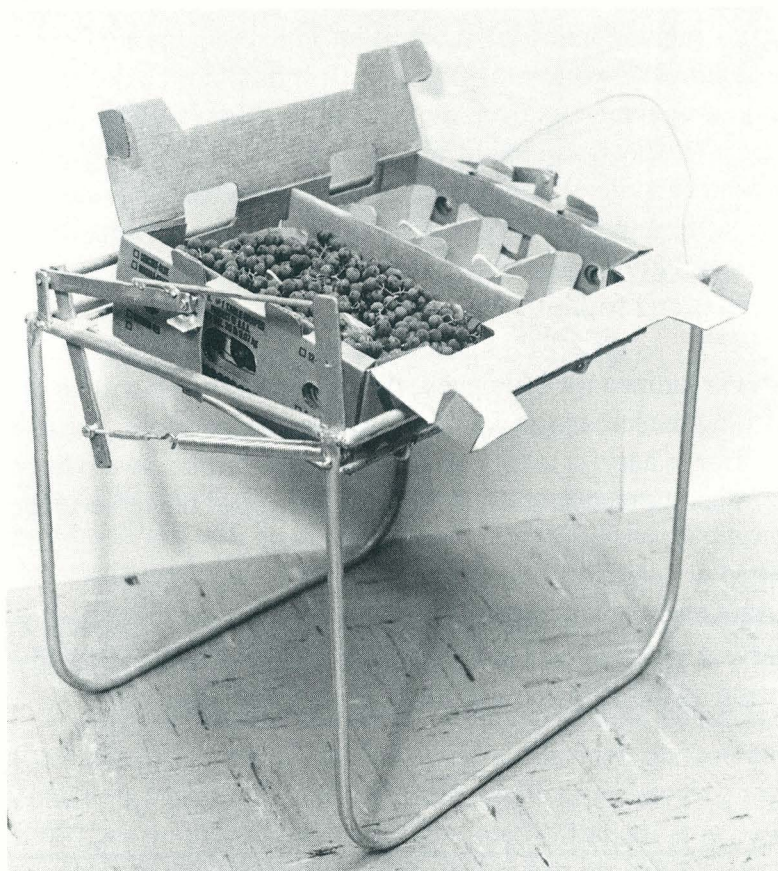


Figure 26 - A portable packing stand with built-in scale.

The packaging boxes should be handy to minimize the effort required to get fruit from vine into the box. Portable packing stands (Fig. 26) may be equipped with a weighing mechanism to indicate when containers have the required weight of grapes. Packing stands should be durable, light in weight, stable on stony, uneven and sloping ground and constructed to place the top of a master container at about waist height for a person of average size.

A grower needs to consider picking efficiency when designing or purchasing containers. Avoid using packaging materials that are awkward to handle in the

vineyard. Most of all, be sure containers have adequate room for the amount of fruit required for the pack. Master containers with inadequate head space will result in a loss of harvest efficiency because the picker must take additional time to decide where to place the last clusters in the pack. If adequate time is not taken, the result will be worse, i.e., grapes will be crushed and subsequent fruit decay will result. Although increasing the volume of a master container will admittedly increase its shipping and storage cost, a larger master container will contribute significantly to fruit quality and harvest efficiency.

- **Vineyard Management** - The critical factors which influence harvest efficiency should be resolved long before pickers enter a vineyard. What is the condition of the vineyard at the

time of harvest? Can pickers work easily on the vineyard floor or is it too rough, weedy or muddy? Have insect pests been controlled adequately not only in regard to fruit quality but also in consideration of the working conditions of the harvest crew? The training system used for the grapevines can have a profound influence on the efficiency of harvest. All those cultural practices which influence the yield as well as the percent of crop suitable for fresh fruit harvest will play a role. How many clusters out of ten can a picker use for the fresh fruit pack? Must the picker inspect three or four clusters before finding one that is acceptable? How far does he or she have to reach to pick clusters? How much trimming is required to remove defects from clusters? How does the size of the clusters compare to the size of the containers to be filled? All of these questions are important in a table grape operation.

- **Field Operations** - The picker should be well supported during the actual harvest operation so that he or she has but one task - picking and packing fruit into the containers. Empty packaging containers should be available to pickers at all times. It should not be necessary for pickers to seek and carry packaging materials from the edge of the vineyard. A simple system of container marking or identification should allow pickers to easily code the containers they have picked. Portions of a vineyard which are unsuited for table grape harvest for any reason should be clearly identified and pickers guided to skip these areas. To facilitate getting picking crews into the vineyard after a rain some growers have used fans on airblast sprayers to hasten the drying of vines and fruit.

The better a harvesting crew is organized for efficiency, the more rewarding will be the experience for both those performing the harvest as well as the grower. Therefore, just as a grower devotes time and energy prior to harvest to hire a harvesting labor force, so too he or she should plan ahead for the efficient operation of this vital component of the table grape enterprise.

Most Concord table grape growers will mechanically harvest the portion of a crop left on the vines after the table grape harvest and deliver it to a processing market. However, some growers have marketed this portion of the crop using a "Pick Your Own" approach.

STORAGE

The Importance of Rapid Cooling

Table grapes experience a rapid decline in quality and shelf life if postharvest cooling is delayed. For example, Nelson, (1985) reporting on California conditions indicates that for every hour grapes are held at 90°F. after picking, they lose one week of storage life at 32°F. Even though harvest weather conditions in New York are not as severe as California, New York grapes will benefit from applying rapid postharvest cooling and humidified cold storage practices.

Postharvest cooling should begin as soon as possible after harvest, preferably less than 2 hours after picking. Loads should be covered to prevent dehydration during truck transit from vineyard to the cooler. Load covers must be removed if the load is parked in the sun even briefly or serious heat damage can result. Cooling should be rapid so that grapes are brought

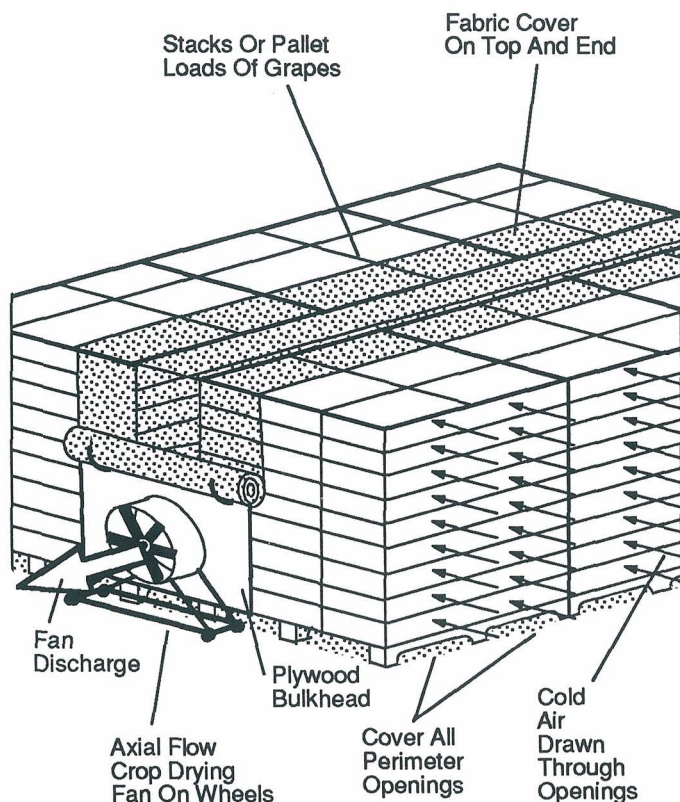


Figure 27 - A schematic diagram of a forced air cooler.

flow to thoroughly penetrate the containers and cool the grapes inside. In this situation almost any small fan will be of some benefit. Even if the recommended 4 to 6 hour cooling is not achieved any improvement in cooling rate will result in better grape quality and longer shelf life. The fan should be turned off when the temperature of the grapes reaches 34°F. to minimize drying of the stems.

Larger operations will find it beneficial to build a dedicated forced air cooler, shown schematically in Figure 27, to draw cold air through the containers of grapes. A guideline for designing such a unit is to select a fan with an air moving capacity of 1 cubic foot per minute (cfm) per pound of grapes being cooled (Mitchell et al., 1972). It is essential that the fan capacity be sufficient for the maximum harvest rate and that the fan deliver the required air volume at a back pressure of 0.25 to 0.50 inches of water gage. If the fan is under sized or incapable of developing the suction necessary to draw cold air through the cartons and grapes

down to 34°F. within 4 to 6 hours after loading the cooler. Cold storage at a constant 32°F. will lower the respiration rate and slow mold growth. Cold storage at 95-98% relative humidity will minimize dehydration losses, retain berry firmness and prolong green, turgid stem condition.

Although it is not always possible to provide ideal post-harvest cooling and storage conditions, one must make every effort to rapidly move the grapes to storage in a timely manner and take maximum advantage of whatever cooling facilities are available.

When the warm grapes are loaded into the cooler an auxiliary fan may be used to speed the cooling process. This fan will be particularly beneficial where the cooling hardware provides insufficient air-

TABLE 9. Examples of Fan Capacities (operating with a back pressure differential of 0.5 inches of a water column) Needed for Forced Air Cooling of Table Grapes.

Pounds of Grapes Cooled in 6 hours	Fan Capacity CFM	Fan Diameter (inches)	Fan Motor (Hp)
1800	1800	12	0.3
3800	3800	14	1.0
5000	5000	18	1.5
7300	7300	18	3.0

inside, cooling will be delayed, quality will suffer, and money invested in the equipment and its operation will be wasted. The fan capacity specifications for several forced air cooling systems are given in Table 9. After the grapes are cooled to 34°F. they should be immediately transferred to humid 32°F. storage.

Conditions for Storage

- **Storage in Lugs** - Concord table grapes can be successfully stored for about one month in field lugs or master containers if the temperature is maintained at 32°F. and the relative humidity is higher than 90%, preferably 95 to 98%. A longer storage period in open boxes is usually limited by one or more of the following factors: (a) stem drying, (b) berry shatter, (c) berry softening and (d) mold and decay.

Reduction in storage life resulting from deterioration of the cluster stem and softening of berries (which occurs when there is a 5-7% loss of berry weight) will be minimized by storage in a high relative humidity environment at 32°F. Water loss from the stem may be further reduced by selecting clusters with cured (mature) stems and by careful handling of the clusters to prevent stem bending during harvest.

Three types of berry shatter (separation of grape berries from the cluster) may occur in storage: wet brush, abscission or broken pedicel. If a wet brush (Figure 28) is left attached to the torus, the shatter was probably caused by rough handling of the clusters. Berry shatter may also occur after an abscission layer forms between the torus and the brush. This type of shatter is aggravated by stem drying and therefore, it can usually be delayed by storage at 32°F. and high relative humidity. If shattered berries have a small piece of pedicel attached, the laterals and pedicels should be examined to determine if the pedicel breakage was associated with dry, brittle pedicels or infected pedicels. The former problem can be reduced by high relative humidity, the latter by fungicidal treatment during the growing season and/or SO_2 in storage.

- **Storage With Sulfur Dioxide** - The following discussion on the use of sulfur dioxide (SO_2) as a fungicide does not constitute a recommendation or endorsement for its use. Contact Cornell Cooperative Extension regarding current regulations regarding the use of SO_2 on grapes in New York State.

Storage of Concord grapes for periods of more than one month can be achieved with the use of SO_2 fumigation to inhibit fungal growth on the clusters. In New York SO_2 pads have only been used to store

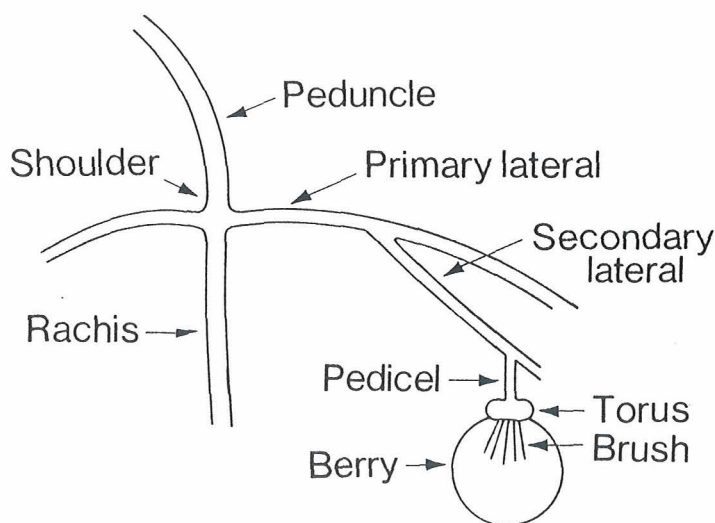


Figure 28 - The nomenclature associated with the cluster stem a grape cluster.

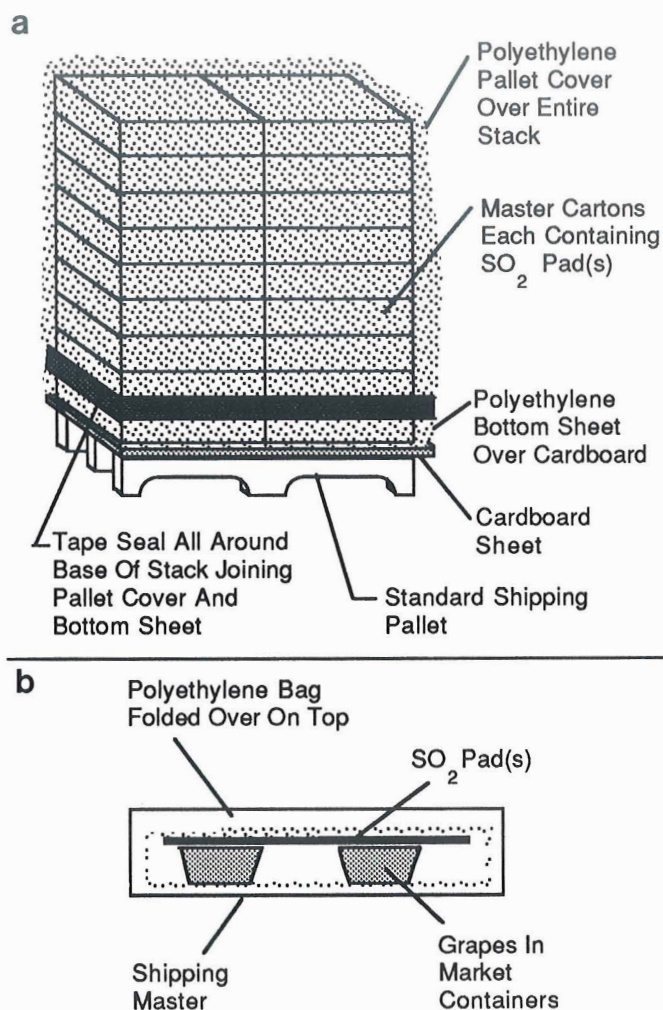


Figure 29 - Two methods of enclosing grapes in polyethylene to maintain levels of sulfur dioxide. (a) Enclosure around a pallet of master containers. (b) Enclose within a master container.

by the pallet. (Figure 29a) A sheet of polyethylene is placed over the cardboard, the master containers are stacked, another sheet of polyethylene is placed over the stack and then the two sheets of polyethylene are folded and taped together to form a tight seal.

The very high relative humidity environment, which develops inside the polyethylene bag, reduces water loss from the berries and the stem tissues and causes the release of SO₂ gas from the SO₂ pads. The SO₂ gas inhibits fungal growth in the clusters. Therefore, the grapes retain their firmness, the cluster stems remain green and decay and mold growth are inhibited until some time after the pads have released all available SO₂ (Table 10).

When grapes are stored in polyethylene bags with SO₂ pads, their storage life is usually limited by deterioration of eating quality resulting from loss of flavor, loss of berry texture, and/or occurrence of SO₂ injury. The visible symptom of SO₂ injury on Concord is a light purple discoloration at cuts and splits in the skin, at loose berry-pedicle junctions and infrequently on intact berries.

grapes for extended periods of time such as for the Thanksgiving market. One and a half pads have been used per 20 pound master container of fruit after the grapes have been cooled. Precooling is needed to minimize the risk of SO₂ injury to the grapes. The SO₂, which is slowly released from the pads, is kept from direct contact with the clusters by placing a sheet of tissue paper between the clusters and the pads.

One system that has been used is to line each master container with a polyethylene bag to prevent sulfur dioxide loss. (Figure 29b) If the retail containers are plastic, they will not absorb the excess sulfur dioxide within this polyethylene bag. Therefore, one sheet of newspaper has been placed in the bottom of the bag for this purpose. The polyethylene bag must be carefully folded or tied shut.

Another approach has been to completely enclose master containers with polyethylene as they are stacked on a pallet. In this situation cardboard is first placed on the pallet to protect the polyethylene from

TABLE 10. Concentration of sulfur dioxide inside polyethylene bags which were either folded or tied, containing Concord grapes held in 1-quart cardboard containers.

Days after pad insertion	Sulfur Dioxide (ppm)	
	Folded bags	Tied bags ¹
1	19.3	20.3
4	3.5	5.0
10	1.8	3.0
18	1.7	3.7
22	1.2	4.5
36	1.1	4.5
41	1.0	1.3
53	trace	1.7
60	trace	1.7

1. Two pin holes placed in polyethylene bags to prevent fermentation due to very low oxygen.

If the use of SO₂ is contemplated, the following procedures are recommended. (1) Follow current regulations. (2) Handle the clusters carefully during harvest and gently handle and transport containers before storage to minimize the loosening of berries and tearing of skin at the point of attachment to the torus. Such injury increases the risk of SO₂ injury to cluster tissues. (3) If plastic consumer containers are used, place a sheet of newspaper in the bottom of the polyethylene bag to absorb any excessive SO₂ that may be initially released from the SO₂ pads. (4) Precool the grapes to 35°F. or lower before enclosing the SO₂ pads and grapes in the polyethylene bags. The polyethylene bags will slow the cooling process and warm grapes will accelerate the release of SO₂ from the pads creating brief but dangerously high SO₂ concentration in the bags. If the polyethylene bags are sealed when the grapes are warm, water condensed on the inside of the polyethylene bags may fall onto the berries, causing them to split. (5) Store treated fruit at 32°F.

The New York experience with the use of sulfur dioxide pads to store Concord grapes has been mixed to date. The Concord grapes in the study presented in Table 11 had trimable amounts of decay and mold on December 10, but they were unmarketable because they had developed an overmature, mushy texture and were lacking of varietal aroma and flavor. If stratification of sulfur dioxide occurs in containers, excessive levels of sulfur dioxide will result in injury to fruit at the top of the container while at the same time a lack of sulfur dioxide at the bottom of the container will result in mold and decay. It is suggested that growers choosing to use this technology obtain experience on a modest scale before proceeding further.

TABLE 11. Percent weight of decay and mold in Concord grapes packed in 1-quart containers and held in prolonged storage at 32°F.

Storage treatment	Evaluation Date	
	Dec. 10	Jan. 18
Open boxes without SO ₂ pads	2.6	6.5
Folded polyethylene bag with SO ₂ pads	1.0	3.7
Tied polyethylene bag ¹ with SO ₂ pads	0.5	2.5

1. Two pin holes per bag to prevent fermentation caused by low oxygen concentrations in the sealed polyethylene bags.

Storage Facilities

• Introduction

Successful table grape storage depends upon rapidly cooling the grapes to 32°F. and holding these grapes at 32°F. in relative humidities of 95-98%. The cooling and storage facility must, therefore, be large enough to accommodate the daily harvested volume and have sufficient refrigeration capacity to cool these grapes in four to six hours. Maintaining quality in storage for periods longer than one week requires precise control of both temperature and humidity.

Depending upon the size of the operation, the storage structure may be a simple homemade insulated room, a prefabricated walk-in cooler or a stand alone cold storage building. In all cases the refrigeration system must have adequate capacity for cooling and maintaining high relative humidity during storage. The equipment should be installed and maintained by a competent technician who understands the short term cooling needs as well as the long term humidity requirements of this valuable but fragile crop.

• Cold Room Construction

The cold room is a well insulated refrigerated enclosure for cooling and/or storing the crop. The quantity of insulation is determined by the "R-value" and for average New York grape storage conditions, it should be 10, 20 and 30 for the floor, walls and ceiling, respectively. If the cooler is used for other commodities during the hot summer months, the recommended R-values in the floor and walls should be increased to 20 and 30, respectively. The thickness of commonly available insulation materials needed to achieve these R-values is given in Table 12. Similar data for other types of insulation may be obtained from building material supply houses.

TABLE 12. Thickness of different types of insulation needed to achieve recommended R-values.

Resistance Value	Fiberglass Batts ¹ (inches)	Extruded Styrofoam ¹ (inches)	Isocyanurate Board ¹ (inches)	Urethane Foam ² (inches)
R-10	3	2	1.25	1.6
R-20	6	3.75	2.50	3.2
R-30	9	5.75	3.75	4.8

1 Rounded to nearest nominal thickness

2 Exact thickness of R=6.25/inch urethane foam

If you decide to build your own cold room, the information presented in Figures 30 and 31 will be of interest. A simple, low cost, but perfectly satisfactory cooler can be built inside an existing barn or shed as shown in Figure 30. If a new building is being planned, a portion of it can be insulated and refrigerated to serve as a cold storage. This option, shown in Figure 31 has several advantages including an insulated concrete floor at grade level and a drain which will permit the use of water for clean up and supplementary humidification. Water should not be used in the cooler shown in Figure 30 because it will quickly saturate the floor insulation.

When building a cold room, you must also install a polyethylene vapor barrier on the warm side of the insulation. This continuous membrane prevents moisture from entering the insulation cavity and condensing in that space. The location of the vapor barrier is always on the warm side of the insulation (Fig. 30 and 31). Note that the vapor barrier membrane is also continuous across the wall, floor and ceiling junctions.

The door will probably be the greatest challenge of all in building a cold room. Cold room doors may be purchased or constructed on site. An effective light-duty door can be made simply by insulating a conventional entry door as shown in Figure 32. If a more durable swinging door is needed, it may be constructed from plywood, 2x4's and foam insulation and mounted with heavy-duty door hardware as shown in Figure 32. Sometimes, it is possible to purchase used cold storage doors which are in good condition and these can also be installed in your grape storage room. Small insulated overhead garage doors with automatic openers are preferred by some as an alternative to heavy, expensive, cumbersome hinged doors.

Used or new prefabricated chambers may also be acceptable storage rooms provided they meet the insulation requirements and are in good condition. Metal-clad, urethane foam insulated, cold rooms are usually acceptable if they are free of serious visible damage. Older cork or fiberglass insulated coolers may or may not be serviceable depending upon the condition of the structure, vapor barrier and insulation. Wet, settled, deteriorated or missing

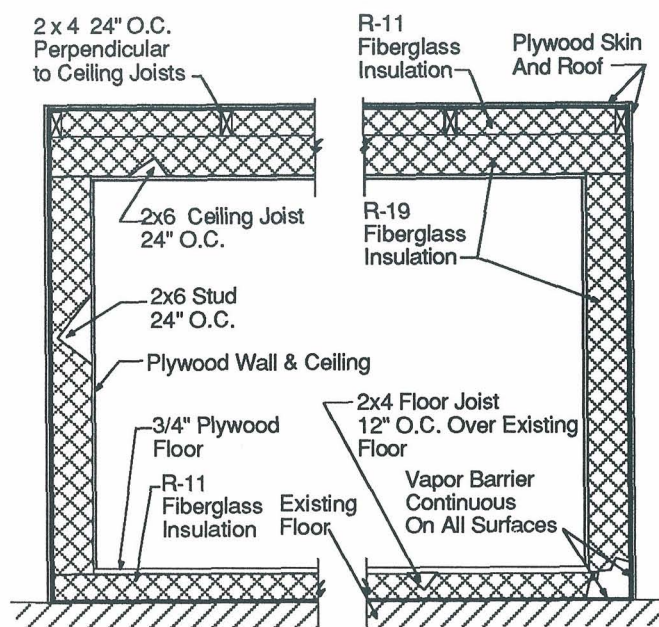


Figure 30- A cross-section of a fiberglass insulated cooler built inside an existing structure.

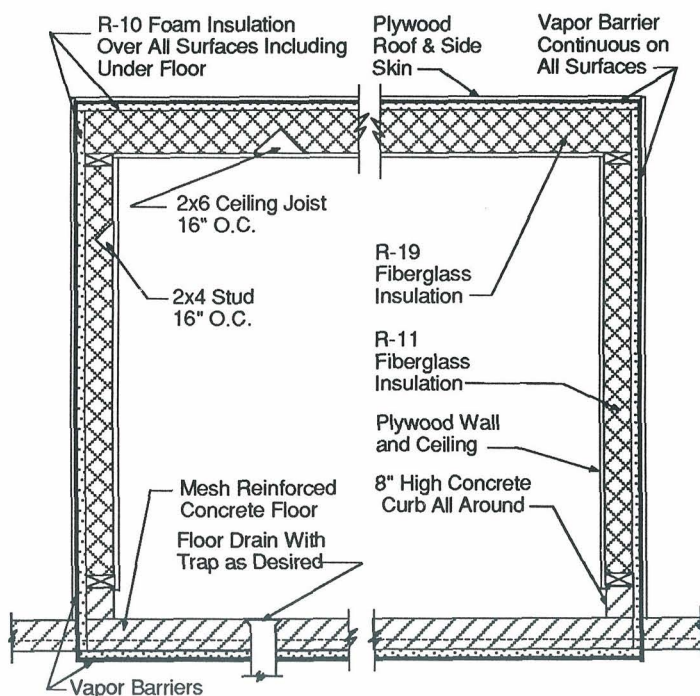


Figure 31 - A cross-section of a foam and fiberglass insulated coldroom.

insulation is indicative of past problems and future headaches you will be purchasing with used equipment in poor condition.

- Holding and Cooling Capacities

The estimated holding and recommended cooling capacity of several sizes of cold rooms is given in Table 13. The storage capacity values are based on 12 to 16 inches of free space allowed between the ceiling and the top of the grape cartons for air circulation in the cooler.

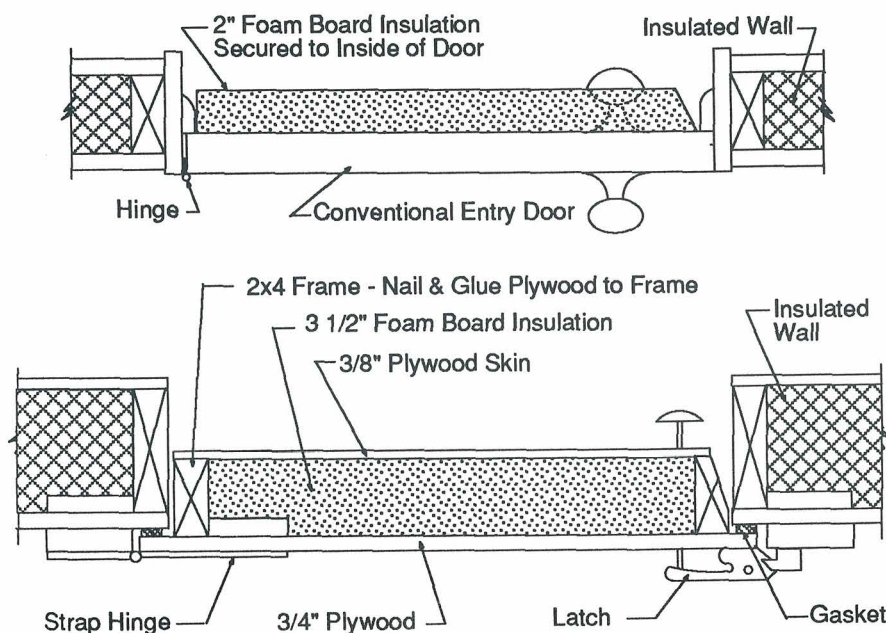


Figure 32 - A schematic of a coldroom door construction.

as the size of the cold room increases. If lower stacking efficiency is anticipated or if wide aisles are needed for lift trucks or if forced air cooling and long term storage are done in the same room, then the storage capacity will be further reduced.

The daily cooling capacity in Table 13 is calculated by assuming a 75°F. field temperature and six hour cooling to 32°F. If faster cooling, warmer harvest conditions, or larger quantities are encountered, the size of refrigeration system must be increased proportionately. If harvest rates and storage capacities exceed the values given for the largest cooler in Table 13, then a separate precooling room should be considered.

- Refrigeration Equipment

Regardless of the system of cooling and room layout selected, the refrigeration system must be designed to maintain the relative humidity in the 95-98% range. In new facilities, this is most often accomplished by installing an "oversized" cooling coil in the storeroom along with a refrigerant back pressure controller to precisely regulate the pressure (and the corresponding temperature) of the refrigerant inside the cooling coil. The oversize coil with back pressure regulator makes it possible to maintain the 32°F. temperature of the grapes with a much warmer coil surface (approximately 28°F.) thereby, reducing the rate of frost build-up on the cooling coil. Less frost on the coil means less water is being removed from the air in the room and correspondingly, less shrinkage of the grapes results during storage.

A six inch air space is also provided around the perimeter of the room to provide for additional air circulation. When cold rooms are stacked with rectangular cartons of grapes in the manner described, approximately 2.2 to 2.6 cubic feet of storage volume is necessary for each 20 pound master or its equivalent. This value decreases

TABLE 13. Examples of cold room size, storage capacity and refrigeration horsepower needed for table grapes.

Cold Room Dimension LxWxH (ft)	Maximum Storage Capacity (Pounds) ¹	Daily Cooling Capacity (Pounds) ²	Compressor Horsepower
6x6x9	2,500	450	0.5
8x8x9	4,600	900	1.0
12x12x9	11,000	1,100	2.0
12x20x12	26,000	3,500	3.0
20x24x12	53,000	7,300	5.0
24x36x12	96,000	10,600	7.5

1 Maximum holding capacity based on usable cooler volume.

2 Quantity of grapes which can be cooled from 75°F to 32°F in six hours with specified equipment.

Refrigeration systems in existing cold rooms or used refrigeration systems probably do not have the capability to maintain the very high humidity levels required for proper grape storage. Although not ideal, there are two partial solutions in this situation. First, grapes can be covered with plastic sheeting after they have been thoroughly cooled to 32°F. It is best to wait one to two days before covering the grapes to make sure all of the field heat is removed and all of the grapes are at 32°F. degrees. Since the respiration rate of grapes at this temperature is relatively low, they can be safely covered to reduce the rate of water loss during storage. The plastic should be loosely draped over the stacks of cartons or individual pallet loads with the side of the stack facing into the cooling air stream completely covered. Heat transfer through the plastic will be adequate to maintain 32°F. provided spaces are left between the covered stacks or pallets. If moisture collects on the underside of the plastic after covering, it is a sign of incomplete cooling and covering should be delayed for one additional day.

Although it is possible to humidify a cold room, it is almost impossible to achieve the desired 95% minimum relative humidity with standard equipment. A very simple and relatively low cost humidification system is shown in Figure 33. However, if the refrigeration system is not designed to operate in the desired humidity range, then any system for adding moisture will constantly battle the cooling system. The result will be an increased rate of ice build-up on the cooling coil, more frequent defrosting and only a partial solution to high humidity needs. Nevertheless, if this is the only available option, one can install a large "cool mist" humidifier (available at discount and drug stores) as shown in Figure 33. Do not install this humidifier if your cooling coil does not have a positive means of defrost (e.g. hot gas, electric or warm water). Room air defrost which is common on many older types of walk-

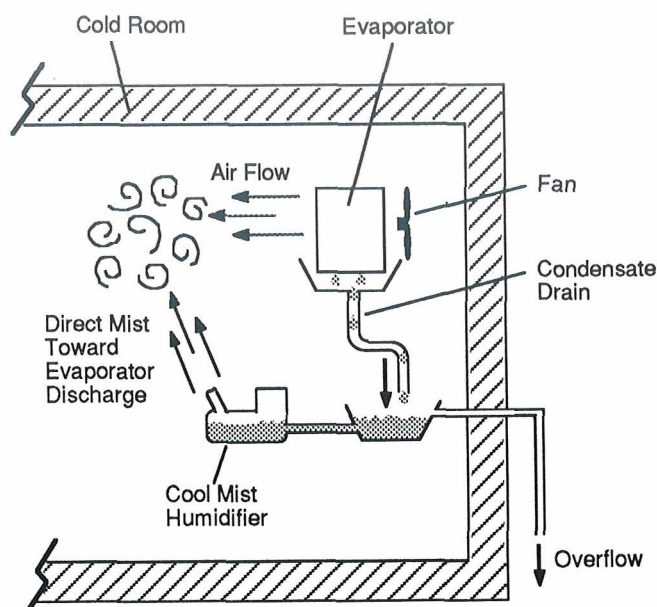


Figure 33 - A simple method for humidifying a small cooler to provide a partial solution for a high humidity cold storage environment.

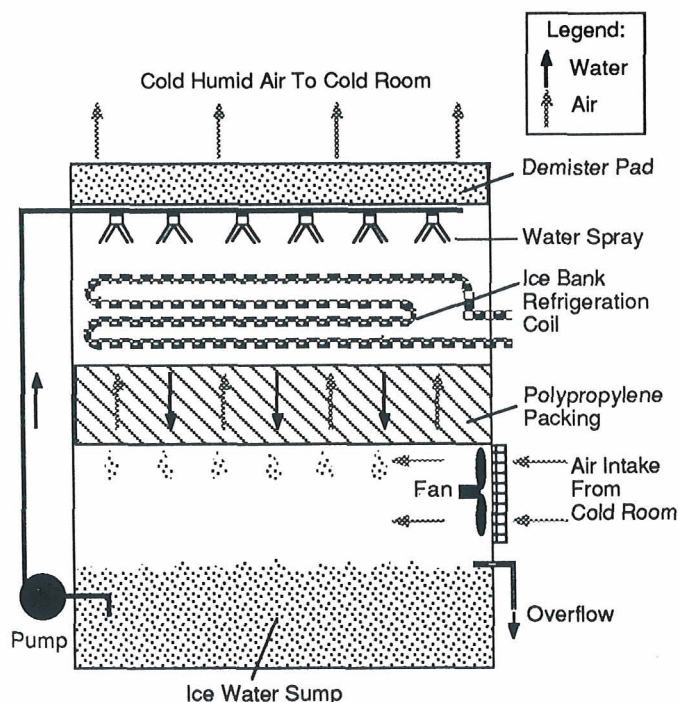


Figure 34 - The operating principle of "Filacell" refrigeration system for monitoring high humidity.

maintained at a constant 32.5°F. and 98-99% relative humidity. Since the air is cooled by melting ice there is no danger of freezing the grapes even though a low storage temperature is being maintained. The high capacity fan in this unit can serve as a forced air cooler thus eliminating

in coolers will never be able to properly defrost the coil because the additional humidity will cause the coil to ice up faster than the room air can melt the ice. In addition, the refrigeration compressor will be turned off during the time when the coil is trying to defrost and dangerously high storage temperatures are likely to result. In this situation, rely upon the plastic cover method and market the grapes as soon as possible after cooling. If long term table grape storage is desired, it will be necessary to replace the refrigeration system with one of adequate size and design for grapes.

Specialized refrigeration systems are available for high humidity table grape storage. Although the current volume of table grape production in New York does not often justify the expense of purchasing one of these systems, a description of such hardware is presented here. The most popular system currently in use is the "Humifresh" or "Filacell" refrigeration system shown schematically in Figure 34. This cooling unit contains a high capacity fan, ice building evaporator coil and internal water spray humidifier. Air from the cold room is drawn into the unit and forced through an ice water saturated bed of polypropylene fiber, moved upward across the ice covered evaporator tubes and through an ice water spray to completely cool and humidify it. The resulting atmosphere is main-

the need for an auxiliary fan. The equipment is expensive, but if applications for off-season crops like strawberries, sweet cherries, asparagus, summer raspberries, etc., in addition to table grapes can be found, the investment may be justified. The capabilities of this system for reducing postharvest shrinkage losses are demonstrated in the research data for Concord table grapes shown in Figure 35.

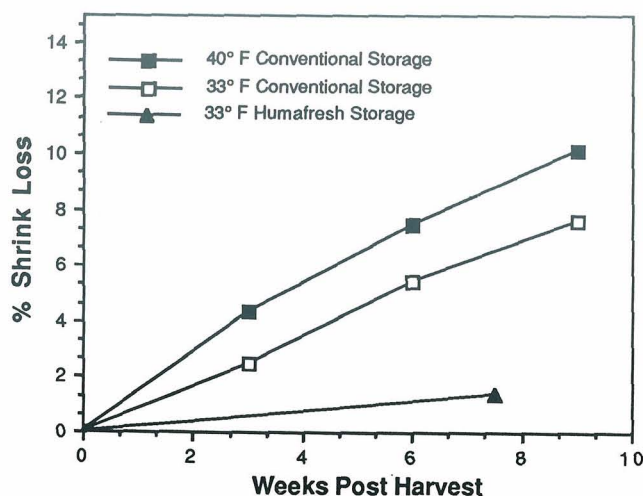


Figure 35 - Concord shrinkage weight loss data for conventional and "Filacell" storage systems.

Those who would like more information on cold storage facilities should consult these Cooperative Extension publications: (a)

Cornell University Agricultural Engineering Bulletin 453, Walk-In Cooler Construction and (b) NRAES Bulletin 22, Refrigeration and Controlled Atmosphere Storage for Horticultural Crops.

Conclusions

Successful table grape storage is possible if sound, disease free product is carefully harvested, rapidly cooled and then stored at a uniform low temperature in a high humidity environment. Quality attributes like berry firmness, aroma, texture and green stem color will all deteriorate with time. The cold storage must be constructed and managed in a way which will slow this deterioration as much as possible.

Storage of Concord grapes at temperatures above 33°F. or at humidities less than 90% has produced unmarketable fruit due to decay in less than 4 weeks, and unmarketable fruit due to poor stem condition in as little as 2 weeks after harvest. By following the above guidelines, Concord grapes have remained marketable for 4 to 5 weeks.

Sulfur dioxide treatment of grapes with pads inside polyethylene liners will usually extend the storage by an additional 3 to 4 weeks. However, the response of Concord grapes to this treatment has not always been positive. At times berries near the top of the pack have shown SO₂ injury while other berries near the bottom of the same pack have been badly decayed. Therefore, if growers choose to use this technology, they ought to proceed cautiously with modest trials at first.

CONCORD-TYPE VARIETIES

Numerous blue grape varieties are quite similar to Concord in flavor and appearance. Some of these may complement Concord production because they ripen earlier or later than Concord (Figure 35), and can therefore extend the harvest and marketing season. Some Concord-type varieties are superior to Concord in such characteristics as disease resistance, handling, storage life, cluster compactness and berry size. Six of these rank highly for viticultural and fruit quality characteristics (Tables 13 and 14) and are described here for grower consideration. These varieties are readily recommended for home vineyards and roadside markets. However, their large scale commercial potential will require more extensive testing.

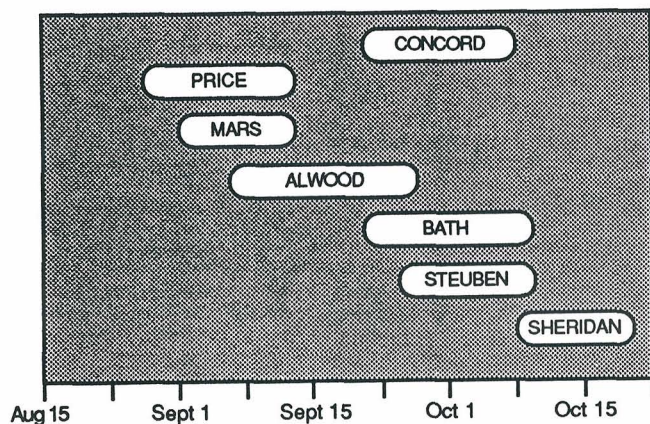


Figure 36 - The approximate ripening dates of Concord and six Concord-like varieties at Geneva, New York.

ALWOOD is an early ripening grape from Virginia (1969) with relatively large clusters and small berries (Plate 4a). It is a productive and hardy vine with good fruit quality. The fruit maintains its quality until late in the season. Vines are quite winter hardy and bear fruit early.

BATH is an attractive, productive grape with good fruit quality and mild labrusca flavor (Plate 4b). It originated in the Cornell University breeding program (1952). Bath is

winter hardy if not overcropped; careful pruning and thinning are required to prevent overcropping. It is also very subject to mite infestation. Storage potential is good.

MARS was named and released in 1985 from the University of Arkansas breeding program (Plate 4c). It is the only seedless grape included in this list. Mars has good fruit quality and attractive clusters with a mild labrusca flavor, ripening early in the season. It is resistant to black rot, downy mildew and powdery mildew, and has been recommended in Arkansas for home markets and limited commercial use. In New York, vines planted in 1982 and 1983 have fruited with minimal winter damage through 1986. Vines tend to bear large crops early and care should be exercised to prevent overproduction during developmental years. Mars is not recommended for full scale commercial plantings, pending more research on production and handling characteristics.

PRICE is an early-ripening grape from Virginia Polytech and State University (1972) having small to medium-sized clusters with large berries (Plate 4d). Fruit quality is among the highest in this class. The skin is relatively tender and flesh is juicy, melting and full flavored. Vines are medium in productivity but have sustained some winter damage in trials at Geneva.

SHERIDAN is an old grape from the New York program (1921), ripening late in the season but producing large, attractive and compact clusters with large berries (Plate 4e). The skin

is tough and the flavor is distinctive yet Concord-like. Vines are vigorous, hardy and productive.

STEUBEN from the New York breeding program (1947), ripens with Concord and produces long, tapering, compact clusters (Plate 4f) (occasionally with brittle stems) that have a sweet, spicy, pleasing flavor. Steuben is hardy and very productive, but requires cluster thinning in some years to 2 clusters per shoot. Steuben does well in storage.

TABLE 13. Characteristics of six Concord-type grape varieties tested at Geneva, New York, 1979-1986. Data presented are based upon balance-pruned vines (20 + 10, maximum of 40 nodes per vine) trained to high and mid-wire cordon systems. Steuben, Bath and Alwood were cluster thinned to 2 clusters per node when necessary.

Variety	1986 live vines	84-86 shoot- less nodes (%)	81-85 Prun- ing wt. (lbs.)	82-86 Yield (tons/ acre)	82-86 Cluster Weight (lbs.)	82-86 Berry Weight ¹ (g)	82-86 Brix ¹	Titra- table Acid ² (g/100 ml)
Price	15/18	29	2.8	5.2	0.28	3.39	18.8	0.93
Steuben	36/36	10	3.0	8.2	0.45	3.09	18.9	0.82
Sheridan	7/7	8	3.4	7.6	0.44	4.01	19.8	1.00
Bath	16/16	12	2.3	8.0	0.42	2.84	18.5	0.81
Alwood	8/8	5	2.3	7.4	0.42	2.47	16.2	0.87
Mars ³	—	—	—	—	0.49	3.50	15.8	—

1. 1 year of data for Sheridan, Bath, and Alwood.
2. Four years data for Price, 3 years data for Bath and Alwood, 1 year data for Sheridan.
3. Data collected at Clarksville, Arkansas, 1983. (Moore, J.N., 1985. HortScience 20:313.)

TABLE 14. Relative susceptibility of Concord and six other Concord-type grape varieties to powdery and downy mildew. ? = Relative susceptibility not established, + = slightly susceptible, ++ = moderately susceptible, +++ = extremely susceptible.

Variety	Downy Mildew	Powdery Mildew
Alwood	+	++
Bath	+	+
Concord	+	++
Mars	+	+
Price	?	++
Sheridan	++	++
Steuben	+	+

GLOSSARY

Apical	The youngest (last-formed) portion of a vine part, i.e., shoot, cane, cluster.
Arm	A branch of the trunk or cordon on which canes or spurs are borne.
Balanced-Pruning	An approach to the pruning of grapevines which determines the pruning severity of a grapevine in response to the vine's growth in the previous growing season.
Basal	The older (first-formed) portion of a vine, i.e., shoot, cane, cluster.
Base Shoot	A shoot from a bud at the base of a cane.
Calyptra	The petals of a grape flower.
Cane	A mature, woody shoot after leaf fall.
Canopy	The foliage of a grapevine as it is situated on a trellis.
Chlorosis	Yellowing of the normally green parts of a plant.
Cordon	An arm of a grapevine, usually horizontally oriented along a trellis wire.
Curtain	A length of canopy that is shoot positioned downward.
Floret	Individual flower of a cluster.
Full Bloom	When the calypttras have fallen from approximately 90% of the florets on the clusters. Concord full bloom normally occurs about mid-June in New York.
Head	The renewal zone of a vine, which is not trained with a cordon.
Infection Period	The time during which a fungal spore germinates, penetrates and invades a vine tissue to establish a parasitic relationship. The length of time is dependent upon factors such as environment and host susceptibility.
Internode	The portion of a cane or shoot between nodes.
Lateral Shoot	A branch of a shoot. It may be less than 1 inch or more than 4 feet long. It may mature into a persistent lateral cane.
Necrosis	The localized death of plant tissue characterized by brownish or black coloration.
Node	The thickened part of the shoot or cane where the leaf and its compound bud are attached.
Pedice	The stem of an individual flower or berry.
Peduncle	That portion of the rachis extending from the shoot to the first branch of the cluster.
Petiole	The stem portion of a leaf.

Pruning	Removal of unwanted parts of the vine.
Rachis	The main axis or stem of a cluster. The cluster framework from which pedicels are attached.
Renewal Zone	That portion of the vine from which fruiting canes and/or spurs are derived.
Shoot	A green growth from a bud on a cane, spur, cordon, arm or trunk. A shoot always bears leaves and tendrils; it may bear fruit.
Shoot Topping	Removal of an apical portion of a shoot.
Soluble Solids	All the dissolved substances in grape juice. For grapes this is frequently measured by a refractometer and is used to approximate sugar concentration.
Spur	A cane pruned to four or fewer nodes. A renewal spur, of one to two nodes, is chosen to produce canes at a particular location. A fruiting spur is chosen to produce fruit shoots.
Tendrils	A long, slender, curled structure at some of the nodes of a shoot. It can firmly attach the shoot to a support.
Training	The establishment of a systematic, reproducible growth form for a grapevine.
Trunk	The relatively permanent above-ground, usually vertically oriented stem of the vine. There may be more than one trunk per vine.
Veraison	The time when grape berries begin to ripen as indicated by color change and fruit softening.
Vine Size	Weight of cane prunings on a vine.

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